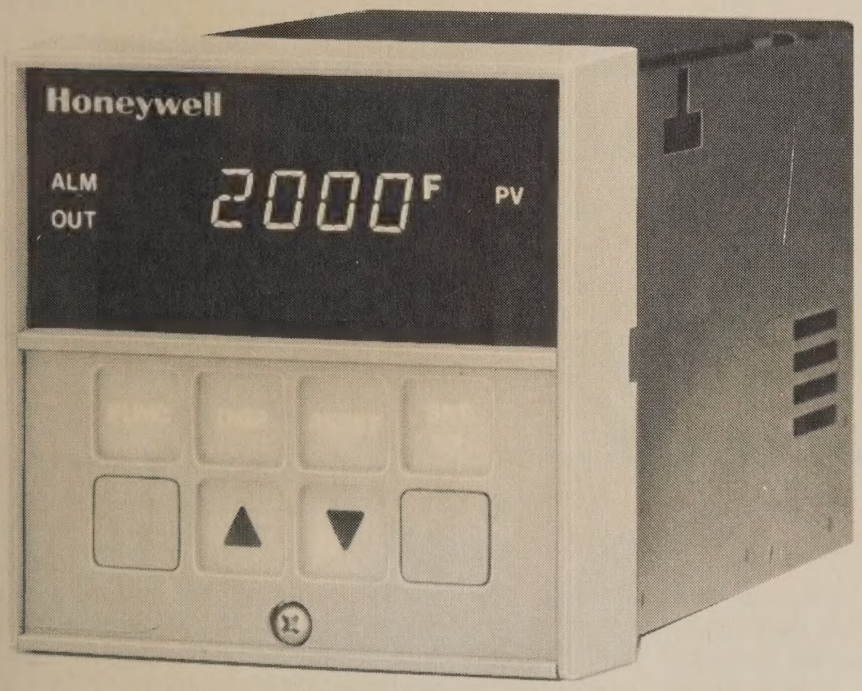
A member of the LEADERLINE product family

51-51-25-15b
6/90

UDC 2000 Mini-Pro

Universal Digital Controller



Product Manual

Limit Control Model

Honeywell

Industrial Controls Division, 1100 Virginia Drive, Fort Washington, PA 19034

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Warranty

The device described herein has been manufactured and tested for correct operation and is warranted as follows:

The UDC 2000 Mini-Pro Universal Digital Limit Controller carries a two year warranty. This warranty includes immediate technical assistance via a toll free telephone number and complete replacement of the controller, if necessary.

Technical Assistance

If you encounter a problem with your Mini-Pro, review all the configuration data under the SET UP groups to verify that your selections are consistent with your application; i.e. Inputs, Outputs, Alarms, Limits, etc. If the problem persists after checking the above, you can get technical assistance by dialing

1 - 800 - 423 - 9883

An engineer will discuss your problem with you. Please have your complete model number, serial number, and configuration data available. The model and serial numbers can be found on the outside of the case. If it is determined that a hardware problem exists, a replacement Limit Controller will be shipped with instructions for returning the defective unit.

Do not return your Limit Controller until the replacement has been received.

Training

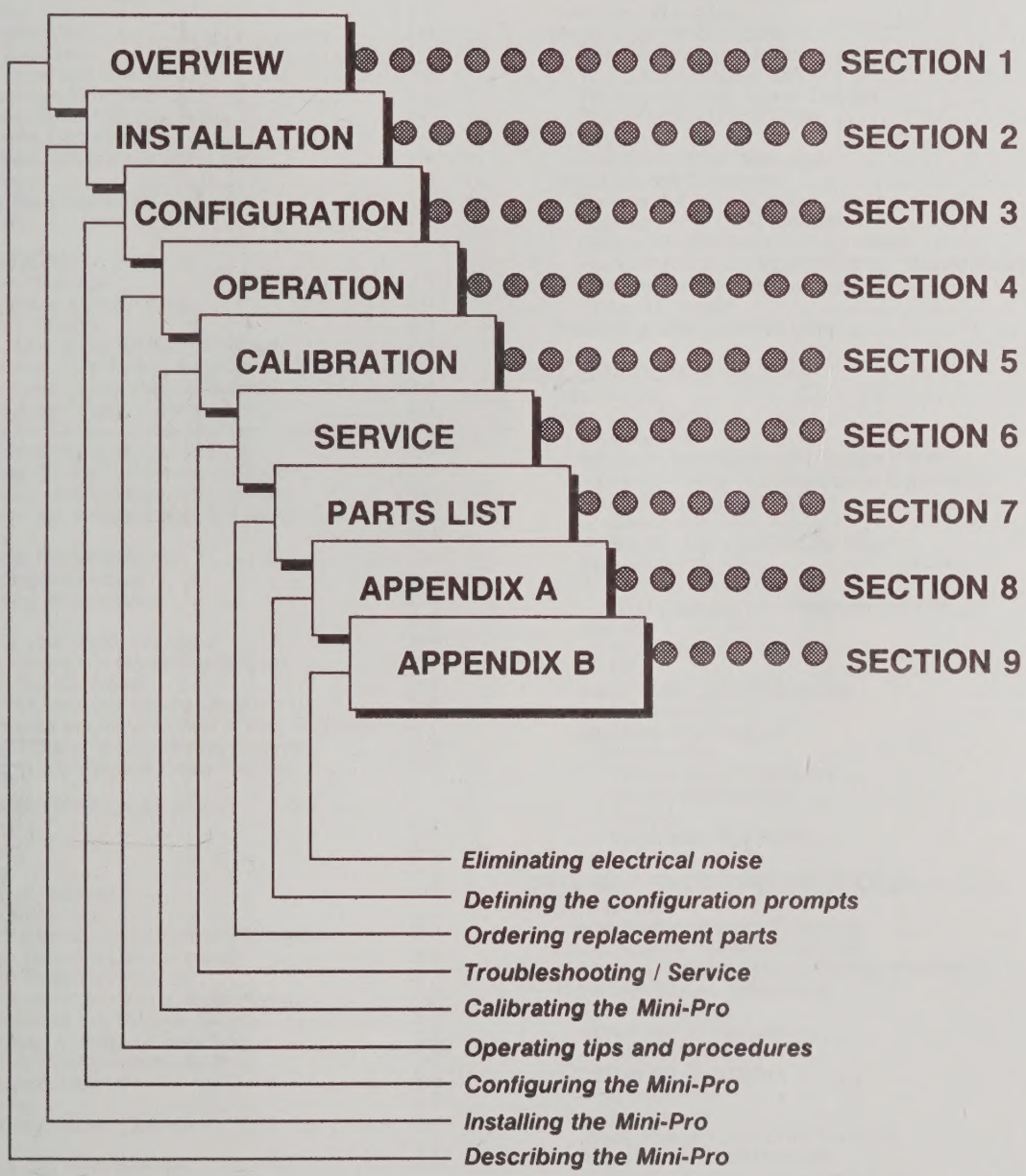
Honeywell offers an implementation self training course on this and other UDC models. The learner paced instruction package consists of the necessary hardware and courseware to step through procedures and familiarize the student with the instrument. The workbook uses practical operation, configuration and application example for the product being learned. For more information contact the Registrar, Honeywell Educational Services, Industrial Automation and Control Division, 1100 Virginia Drive, Fort Washington, PA 19034.

UDC 2000 LIMIT CONTROLLER FOREWORD

How This Manual Is Organized

The UDC 2000 Mini-Pro Universal Digital Limit Controller Product Manual consists of 9 sections numbered 1 through 9 titled as shown below and appearing on each page.

Page numbers include a section number prefix so you can readily access the described information.



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OVERVIEW SECTION 1

Introduction

The UDC 2000 Mini-Pro Universal Digital Limit Controller is a **low cost** member of Honeywell's family of Leaderline products. It monitors and limits temperatures and other variables in applications such as environmental chambers, plastic processing machines, furnaces and ovens, and packaging machinery.

This Limit Controller has a latching output relay which is de-energized whenever the PV goes above (High Limit) or below (Low Limit) a selected set point value. When the limit is exceeded (High or Low), the lower display indicates the word "LIMIT".

Reset of the latching output relay is through a [RESET] key on the front of the controller or an external switch (if the option is present)

An additional non-latching ALARM relay with two set points alerts you to critical process conditions..

The Mini-Pro Limit Controller has a dedicated configuration display which provides plain English prompts providing unmatched operating simplicity. Programmed sequences of displays assure quick and accurate entry of all configurable parameters. Simple keystrokes let you change the operating parameters to meet your limit control needs.

Self Diagnostics, fault tolerant design, and keyboard security provide maximum assurance of trouble-free operation.

Features/Benefits

Easy to Configure - A bright dedicated configuration display provides straightforward English prompts that allow easy set-up with minimum time and effort.

Universal Inputs - Accepts 9 thermocouple types, or RTD inputs through simple configuration.

Set Point Limits - Configurable high or low set point limits.

Power Up Logic - lets you select " output in alarm at power up" or "output to state prior to power down".

Thermocouple Failsafe - Upscale burnout for thermocouple actuations on High Limit, downscale burnout on Low Limit.

High Noise Immunity - The Mini-Pro is designed to provide reliable performance in industrial environments that often affect highly noise-sensitive digital equipment.

Decimal Point Location - Configurable for none, one, or two places.

Diagnostic/Failsafe Outputs - Continuous diagnostic routines detect failure modes, trigger a failsafe output value and identify the failure to minimize troubleshooting time.

Highly Secure - Non-volatile memory assures data integrity during loss of power. Keyboard security inhibits accidental or unauthorized changes to the process.

Optional Features

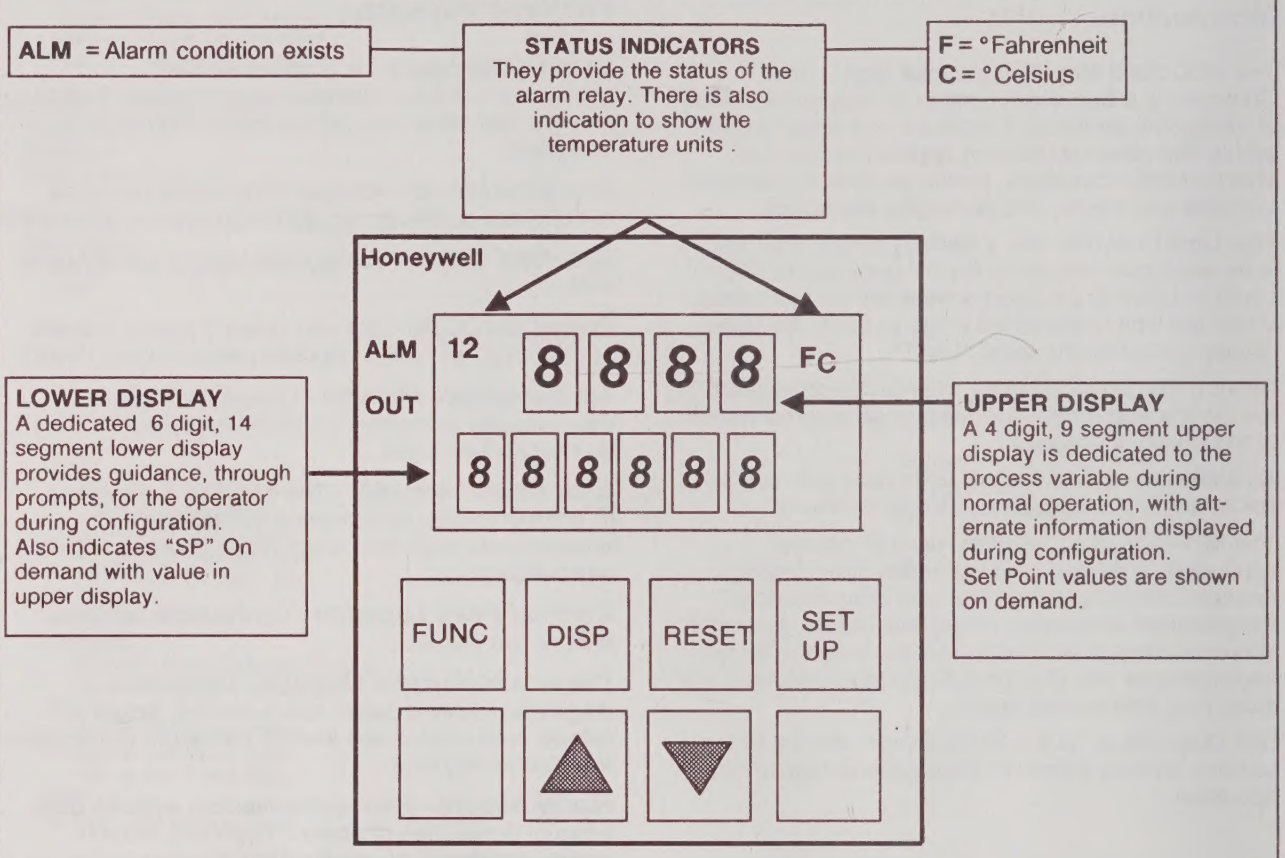
External Reset (Contact Input) - This feature resets the latching relay on contact closure.

PV (Auxiliary) Output - This process variable auxiliary output can be scaled from 0 to 5 Volts or 1 to 5 Volts for 0 to 100% for any range desired.

Alarm Selection - One non-latching alarm relay to activate external equipment when preset High/Low set points are reached. There is an indicator for the alarm on the operator interface. There is a fixed Alarm Relay Hysteresis of 0.5% of Input (PV) span.

Solid State Relay Output - Optional output rated at 1 Amp at 120/240V or 10 Amps at 120/240V. Minimum load 0.1 Amp.

OPERATOR INTERFACE OVERVIEW


ALM = Alarm condition exists
STATUS INDICATORS
They provide the status of the alarm relay. There is also indication to show the temperature units .
F = °Fahrenheit
C = °Celsius
Honeywell
ALM
OUT
12
8 8 8 8
Fc
8 8 8 8 8 8
LOWER DISPLAY
A dedicated 6 digit, 14 segment lower display provides guidance, through prompts, for the operator during configuration.
Also indicates "SP" On demand with value in upper display.
UPPER DISPLAY
A 4 digit, 9 segment upper display is dedicated to the process variable during normal operation, with alternate information displayed during configuration.
Set Point values are shown on demand.
FUNC
DISP
RESET
SET UP

Key Functions

Six keys enable complete configuration and operation.

FUNC	Selects functions within each configuration SET UP group.		Not used
DISP	Allows viewing of the set point or Process Variable. Returns the controller to normal operation from SET UP mode.	▲	Increases the set point or configuration values.
RESET	Deactivates the latching relay except in Set Up mode. Also used to restore original value or selection when in SET UP mode.	▼	Decreases the set point or configuration values.
SET UP	Scrolls through the configuration groups.		Not used.

Figure 1 - 1 Operator Interface

MODEL NUMBER INTERPRETATION

MODEL SELECTION		Key No. DC200X-X	TABLE I	TABLE II	TABLE III	TABLE IV	AVAILABILITY	
				XXXX	XXXX	XX		
Key Number	**Output Type**		Hi Limit Controller +				DC2005	↓
			Lo Limit Controller +				DC2006	↓
Table I	**Alarms**		None				0	•
			1 Alarm Relay				1	•
Table II	**External Interface**		None				0 - - -	•
			PV Output or Contact Input				2 - - -	•
			None				- 0 - -	•
			None				- - 0 -	•
			None				- - - 0	•
Table III	**Approval Bodies**		None				0000	•
			CSA *				C300	•
			FM				00FM	•
Table IV	**Options**		None				00	•
			1 Amp S.S. Relay Output Kit				01	•
			10 Amp S.S. Relay Output Kit				10	•
			Customer I.D.				35	•

*** Planned options - not part of original release**
+ Available with temperature ranges only

CONDENSED SPECIFICATIONS

Operating Conditions

	Reference Conditions	*Rated Conditions*	*Operative Limits*	*Transportation and Storage*
Ambient Temperature	22 ±3°C 72 ±5°F	15 to 55°C 58 to 131°F	0 to 55°C 32 to 131°F	-40 to 66°C -40 to 151°F
Vibration				
Frequency (Hz)	0	0 to 70	0 to 200	0 to 200
Acceleration (g)	0	0.1	0.5	0.5
Mechanical Shock				
Acceleration (g)	0	1	5	20
Duration (ms)	0	30	30	30
Voltage (Vac)	120 ±1 240 ±2	102 to 132 204 to 264	102 to 132 204 to 264	-- --
Frequency (Hz)	50 ±0.2 60 ±0.2	49 to 51 59 to 61	48 to 52 58 to 62	-- --

CONDENSED SPECIFICATIONS (CONTINUED)

Field Selectable Input Actuations

PV Input	Range °F	Range °C
Thermocouples		
B	150 to 3300	66 to 1815
E	-100 to 1832	-73 to 1000
E(Low)	-100 to 1100	-73 to 593
J	0 to 1600	-18 to 871
J(Low)	0 to 900	-18 to 482
K	0 to 2400	-18 to 1316
K(Low)	-20 to 1000	-29 to 538
NiNiMoly (N)	32 to 2500	0 to 1371
R	0 to 3100	-18 to 1704
S	0 to 3100	-18 to 1704
T	-300 to 700	-184 to 371
T (Low)	-80 to 500	-63 to 260
W5W26	0 to 4200	- 18 to 2316
RTD		
100 Ohm Pt.	-300 to 900	-184 to 482
100 Ohm Pt. (Low)	0 to 300	-18 to 149

Accuracy

±0.50% of span typical (±1 digit for display)

Power Requirements

120/240 Volts, 50 or 60 Hz

Isolation

Inputs and Outputs are not isolated from each other

INSTALLATION SECTION 2

Inspect for Shipping Damage and Check for Accessories

If the Mini-Pro Limit Controller has not been removed from its shipping carton, inspect the carton for damage, and remove the Mini-Pro. Inspect the Mini-Pro for any obvious shipping damage and report any damage due to transit to the carrier. Check that a bag containing mounting hardware is included in the carton with the Limit Controller.

Model Number Identification

Make sure the model number shown on the nameplate on the outside of the case agrees with what you have ordered. The model number interpretation is on page 1-3.

Preliminary Checks

Before you install the Limit Controller make the following preliminary checks. The procedure is shown on page 2-3.

ALL MODELS

CHECK OPERATING VOLTAGE SELECTION

Check the Operating Voltage Jumper position. The Mini-Pro Limit Controller is shipped configured for use with 120 Vac. If you want to use 240 Vac, you will have to position the J1 connector on the main printed wiring board to the 240 Volt position, as shown in figure 2-1.
CAUTION: Operating a 120 Volt controller at 240 Volts will damage the unit.

CHECK THE INPUT TYPE SELECTION

You must check an internal DIP switch to make sure the switches are set for the correct input type. The switches are located at position J8 on the main printed wiring board. Set the switches for the input desired. See figure 2-1 .

CHECK THE RELAY OUTPUT JUMPER

Without Solid State Relay

Make sure pin #1 on the jumper at J7 on the main printed wiring board is plugged into pin #1 on connector J7 as shown in Figure 2-1.

With Solid State Relay

Remove the relay output jumper on connector J7 and position the jumper supplied with the solid state relay kit as shown in Figure 2-1. Wire the relays as shown in Figure 2-5.

Preliminary Checks (Continued)

CHECK LIMIT CONTROL RELAY ACTION

Position the jumper at J6 on the main printed wiring board for **(NO)** Normally Open or **(NC)** Normally Closed contacts on the ***LIMIT CONTROL*** relay.

See Table 2-1 for contact information and figure 2-1 for jumper placement.
The controller has been shipped with the LIMIT CONTROL relay configured for **normally closed** contacts. See Control Relay Caution Note, page 2-9.

OPTIONS

MODEL DC200X-1-XXXX-XXXX-XX

CHECK ALARM RELAY ACTION

Position the jumper at J5 on the option Printed wiring board for **(NO)** Normally Open or **(NC)** Normally Closed contacts on the relay.
J5 is the ALARM contact selector.

See Table 2-2 for alarm contact information and figure 2-1 for jumper placement.
The controller has been shipped with ALARM relay configured for **normally closed** contacts.
See Alarm Relay Caution Note, Page 2-9.

MODEL DC200X-X-2XXX-XXXX-XX

CHECK OPTIONAL PV OUTPUT OR CONTACT INPUT SELECTION

Position a jumper at J6 on the option printed wiring board to select
DIG IN (External Reset) or
AUX OUT (PV Output).
See figure 2-1 for jumper placement.
The controller has been configured for
PV OUTPUT (AUX OUT)

Table 2-1 Limit Control Relay Contact Information Chart

UNIT POWER	LIMIT CONTROL RELAY JUMPER	*VARIABLE NOT IN LIMIT STATE*		*VARIABLE IN LIMIT STATE*	
		RELAY CONTACT	INDICATOR	RELAY CONTACT	INDICATOR
Off	N.O.	Open	Off	Open	Off
	N.C.	Closed		Closed	
On	N.O.	Closed	Off	Open	On
	N.C.	Open		Closed	Off

NOTE: *Limit control relays are designed to operate in a failsafe mode. This results in momentary (5 seconds Maximum) limit actuation when power is initially applied, until the unit completes self diagnostics. If power is lost to the unit, the Limit Relay will function.*

Table 2-2 Alarm Relay Contact Information Chart

UNIT POWER	ALARM RELAY JUMPER	*VARIABLE NOT IN ALARM*		*VARIABLE IN ALARM STATE*	
		RELAY CONTACT	INDICATORS	RELAY CONTACT	INDICATORS
Off	N.O.	Open	Off	Open	Off
	N.C.	Closed		Closed	
On	N.O.	Closed	Off	Open	On
	N.C.	Open		Closed	

NOTE: *Alarm relays are designed to operate in a failsafe mode. i.e. De-energized during alarm state. This results in alarm actuation when power is OFF or when initially applied, until the unit completes self diagnostics. If power is lost to the unit, the alarms will function.*

PROCEDURES

Before you install the Limit Controller, loosen the screw on the front of the controller, pull the chassis out and make any preliminary checks necessary. When you return the chassis to the case, make sure it slides under the guide clip in the case. The figure below shows all the checks listed on page 2-1.

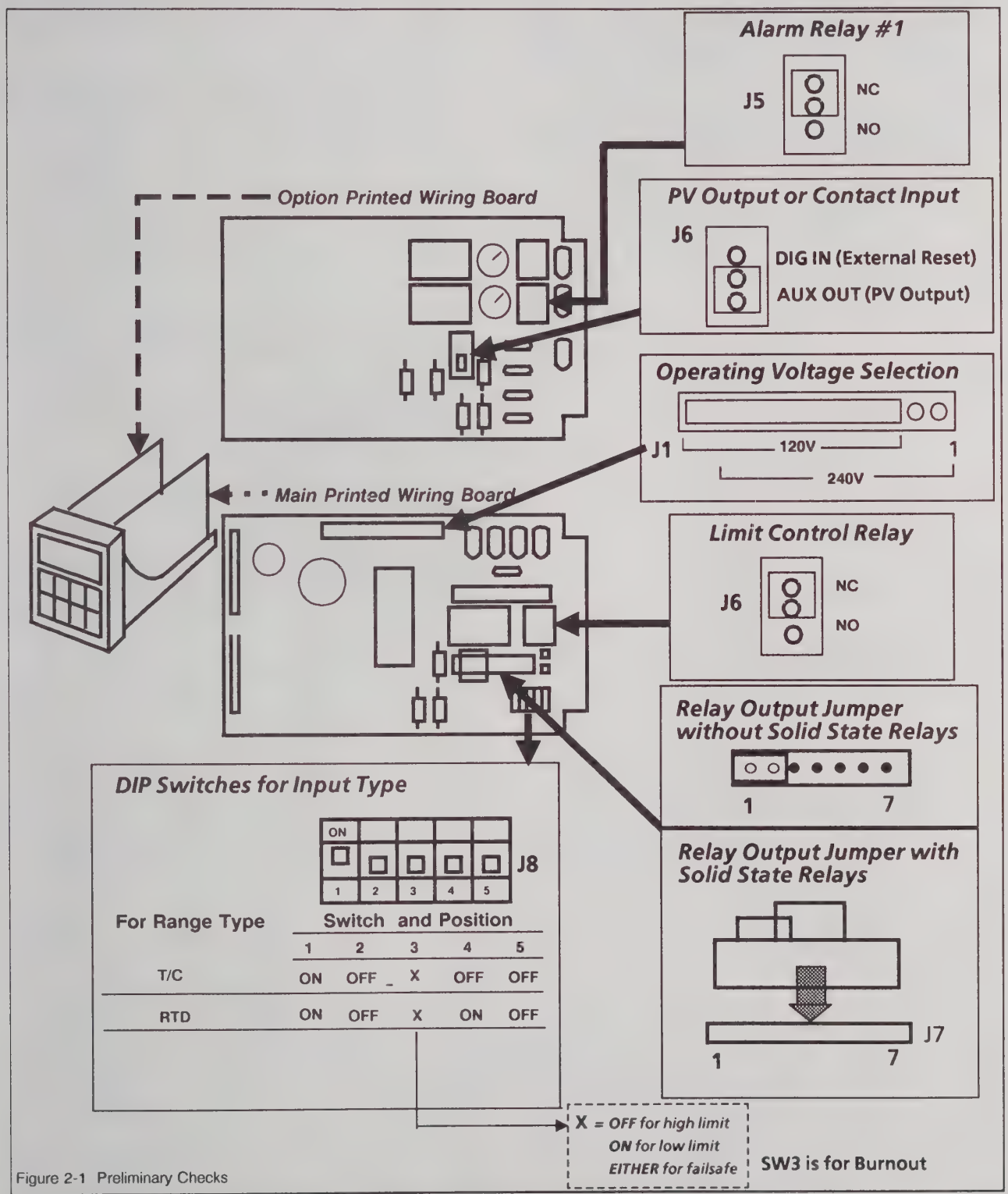


Figure 2-1 Preliminary Checks

Mounting

Physical Considerations

The Mini-Pro Limit Controller can be mounted on either a vertical or tilted panel using the mounting kit supplied with the controller. Adequate access space must be available at the back of the panel for installation and servicing activities. The overall dimensions and panel cutout requirements for mounting the Limit Controller are shown on the dimension data drawing in figure 2-2. The enclosure into which the Mini-Pro Limit Controller is mounted must be grounded according to CSA standard C22.2 No. 0.4 or Factory Mutual Class No. 3820 paragraph 6.1.5.

Mounting

Before mounting the Limit Controller, refer to the nameplate on the outside of the case and make a note of the model number. It will help later when selecting the proper wiring diagram.

1. Mark and cut out the Limit Controller mounting hole in the panel according to the dimensions specified on the dimension drawing below.
2. Loosen the screw on the front of the Limit Controller and pull the chassis from the case.
3. Orient the case properly and slide it through the panel hole from the front.
4. Remove the mounting kit from the shipping container and install the kit as follows:
   a. Install the screws into the threaded holes of the clips.
   b. Insert the prongs of the clips into the two holes in the top and bottom of the case.
   c. Tighten both screws to secure the case against the panel.
   d. Carefully slide the chassis assembly under the guide clip and into the case, press to close and tighten the screw.

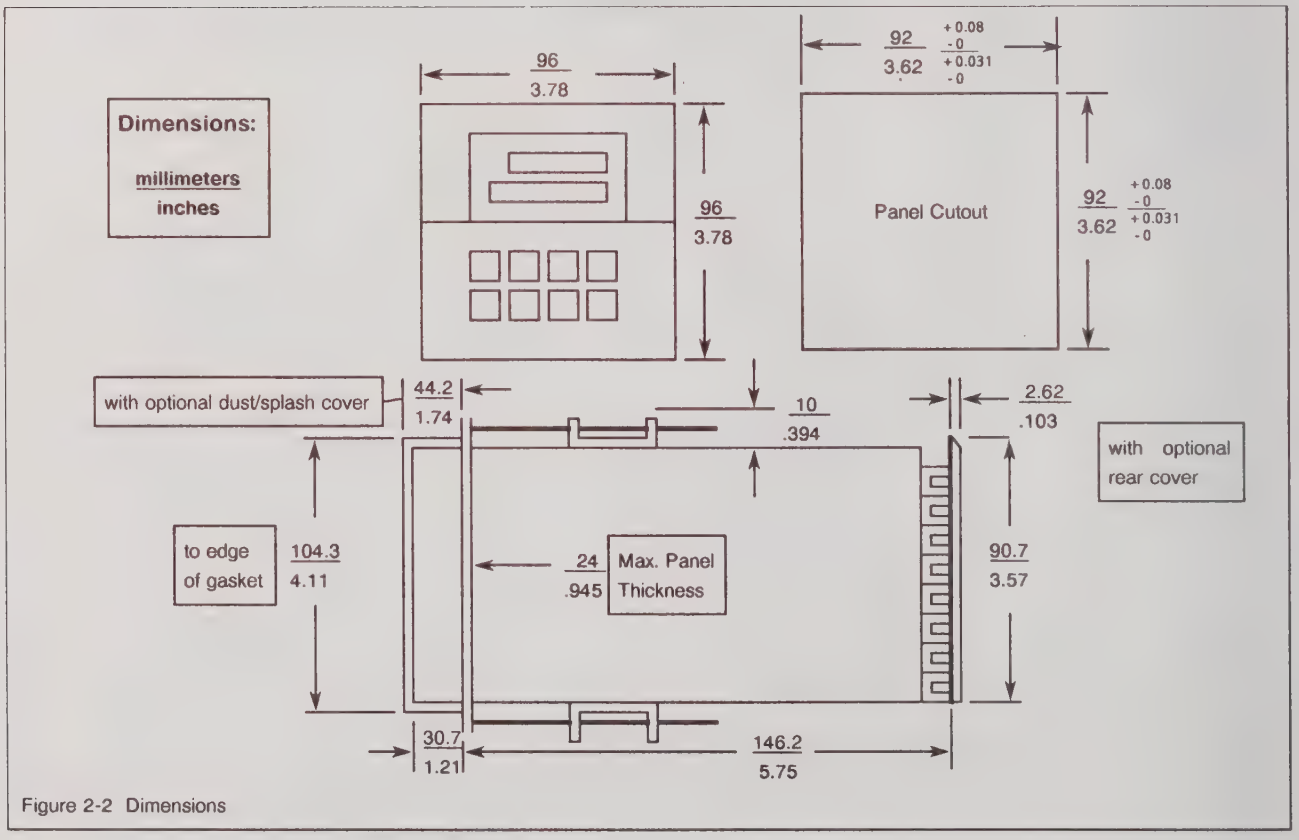


Figure 2-2 Dimensions

Mounting (continued)

Mounting Accessories

In addition to the panel cutout described above, other aids for mounting the UDC 2000 Limit Controller include the following supplemental accessories and kits:

- A rear terminal cover kit, part no. 30756091-001
- A splash cover, part no. 24400107-001
- An adapter kit for DIN 43700 Panel Cutout(5.43 in. X 5.43 in.) to fit Dialatrol, Barber-Coleman 560, and Leeds and Northrup E Max V cutout, part no. 30755223-001
- An adaptor plate with hardware to cover UDC 300 or UDC 4000 Cutout (3.62 in. X 5.43 in.), part no. 30755223-002
  For additional 1/4 DIN adaptor plates with mounting hardware (see table 2-4)

WIRING

Identify your Model Number

To determine the appropriate diagrams for wiring your Limit Controller:

- Refer to the model number interpretation shown on page 1-3. The model number of the Limit Controller contains selection codes that identify the Input type, Alarm selection, and optional selections. The model number of your controller can be found on the outside of the case.

NOTE: MAKE SURE THE INPUTS AND OUTPUTS ARE ISOLATED FROM EACH OTHER.

Taking Electrical Noise Precautions

Electrical noise is unabated electrical signals which produce undesirable effects in measurement and control circuits. Digital equipment is especially sensitive to the effects of electrical noise. Your Mini-Pro Limit Controller has built-in circuits to reduce the effects of electrical noise from various sources. To further reduce these effects:

- Separate External Wiring - separate connecting wires into bundles (see table 2-3), and route the individual bundles through separate conduits or metal trays;
- Use Suppression Devices - for additional noise protection, you may want to add suppression devices at the external source. Appropriate suppression devices are commercially available.

Table 2-3
PERMISSIBLE WIRE BUNDLING

Bundle No.	*Wire Functions*
1	a. Line power wiring b. Earth ground wiring c. Control relay output wiring d. Line voltage alarm wiring
2	Analog signal wire, such as a. Input signal wire(T/C, 4-20mA,etc) b. 4-20mA output signal wiring c. Digital input signals
3	a. Low-voltage alarm relay output wiring b. Low voltage wiring to solid state type control circuits

Wiring the Controller

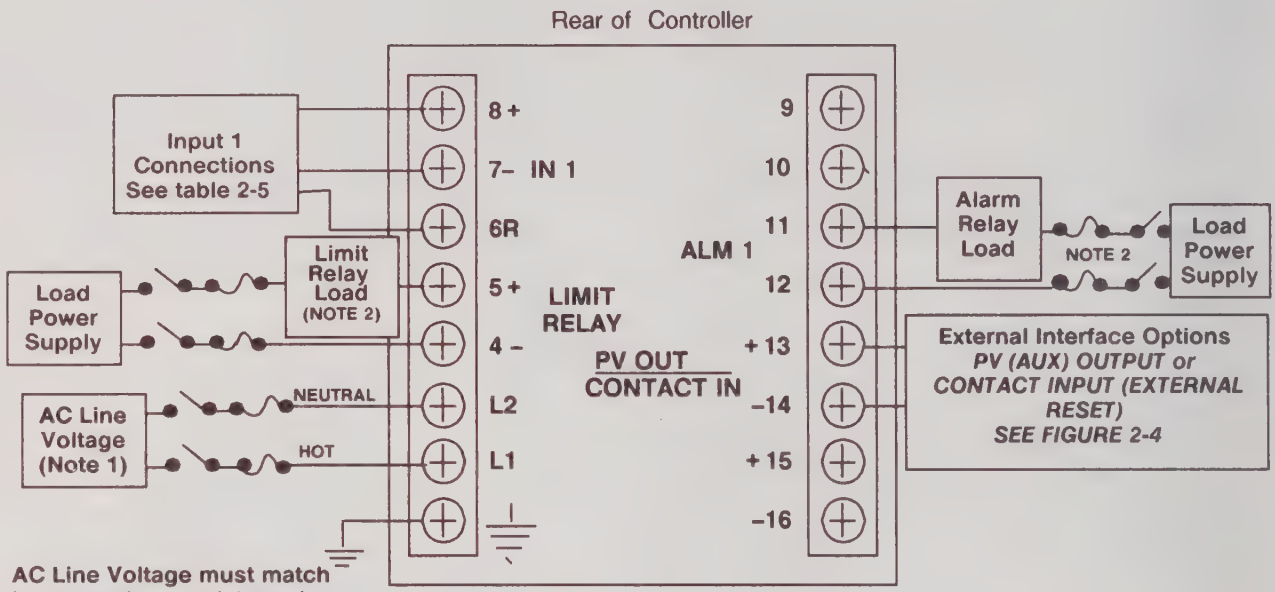
- Using the information contained in the model number, select the appropriate wiring diagrams from the connection diagrams in figure 2-3, 2-4, and 2-5 and wire the controller accordingly.

LIMIT CONTROLLER
Models DC2005, DC2006 FIGURE 2-3
EXTERNAL INTERFACE OPTIONS
Model DC200X - X - 2XXX FIGURE 2-4
SOLID STATE RELAY OUTPUT
Models DC2005, DC2006 with SSR Kits FIGURE 2-5

TABLE 2-4 1/4 DIN Adaptor Plates

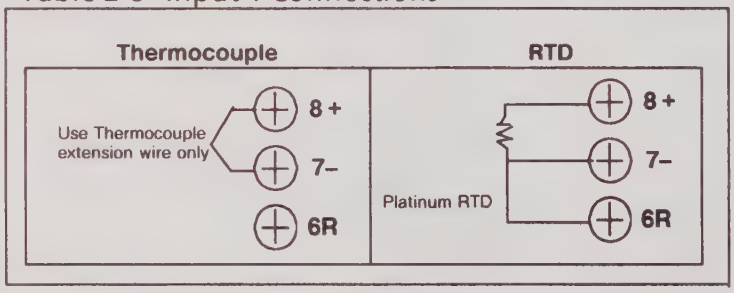
DIMENSIONS				MAXIMUM CUTOUT				PART NUMBER
INCHES		CENTIMETERS		INCHES		CENTIMETERS		
WIDTH	HEIGHT	WIDTH	HEIGHT	WIDTH	HEIGHT	WIDTH	HEIGHT	
5.25	8.875	13.3	22.5	4.5	8.125	11.4	20.6	24400104-001
8.25	7.25	21.0	18.4	7.5	6.5	19.0	16.5	24400104-003
8.375	8.875	21.3	22.2	7.625	8.125	19.3	20.6	25500104-004
9.875	10.875	25.1	27.6	9.125	10.125	23.1	25.6	24400104-005

LIMIT CONTROLLER WIRING DIAGRAM - MODELS DC2005 AND DC2006



AC Line Voltage must match instrument nameplate and internal power selection , 120V or 240V
Ground separately and directly to earth.
Ground using 12 gauge stranded wire

Table 2-5 Input 1 Connections

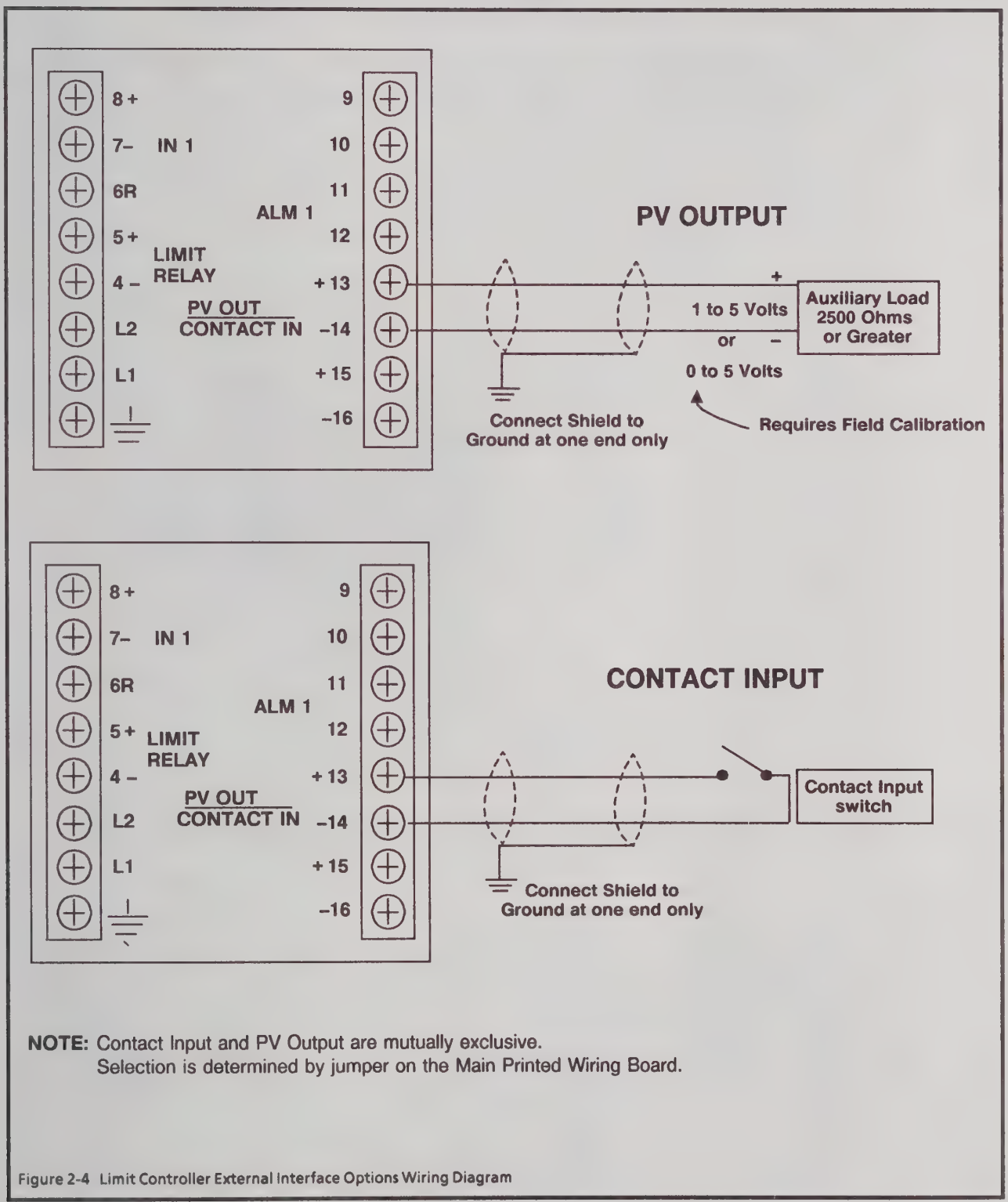


NOTE 1. Before powering the unit, see "Preliminary Checks" in this section of the product manual. Set DIP switches for input type. Check jumpers for operating voltage and relay contacts.

NOTE 2. Limit relay is shipped having N.C. contacts configured. Alarm relay is shipped with N.C. contacts configured. N.O. or N.C. contacts are selectable by means of a jumper on the main and option printed wiring boards. See "Preliminary Checks" in this section of the product manual for details. Each alarm is a SPST relay, rated at 5 amps at 120V, and 2.5 amps at 240 Vac.

Figure 2-3 Limit Controller Wiring Diagram

LIMIT CONTROLLER WIRING DIAGRAM (EXTERNAL INTERFACE OPTIONS)

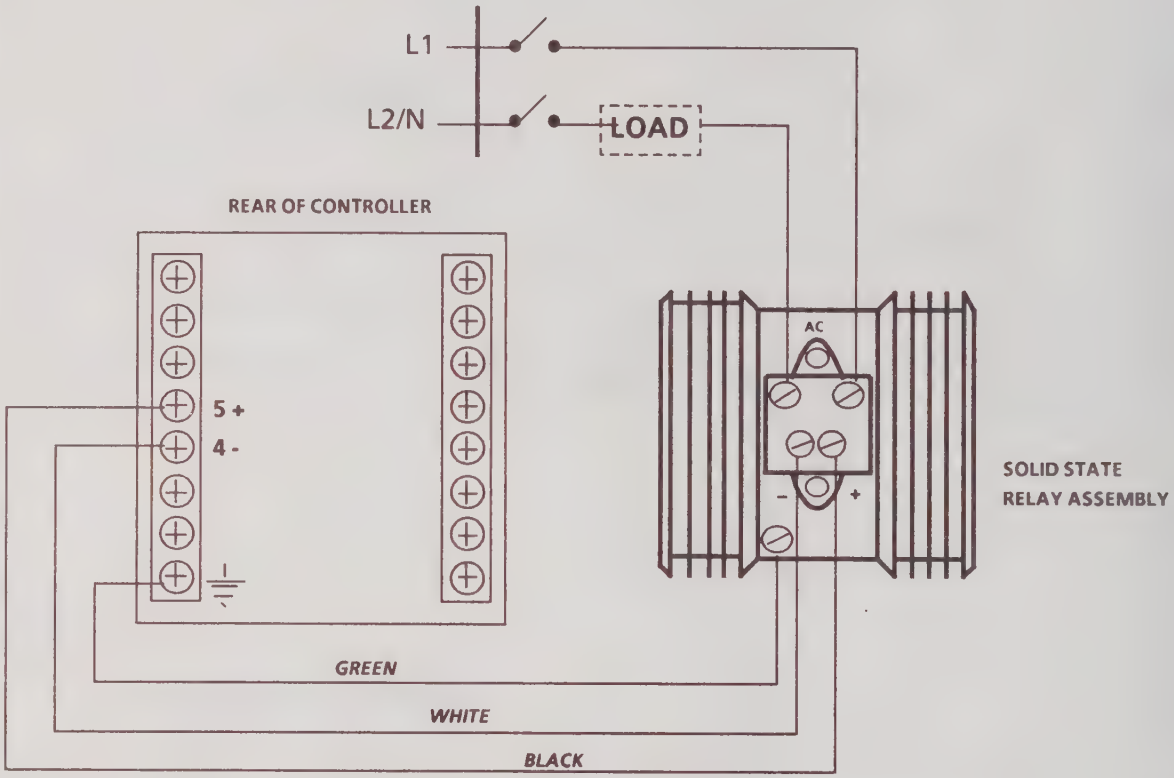


NOTE: Contact Input and PV Output are mutually exclusive.
Selection is determined by jumper on the Main Printed Wiring Board.

Figure 2-4 Limit Controller External Interface Options Wiring Diagram

LIMIT CONTROLLER WIRING DIAGRAM (SOLID STATE RELAY OUTPUT WIRING)

10AMP SOLID STATE RELAY ASSEMBLY



1AMP SOLID STATE RELAY ASSEMBLY

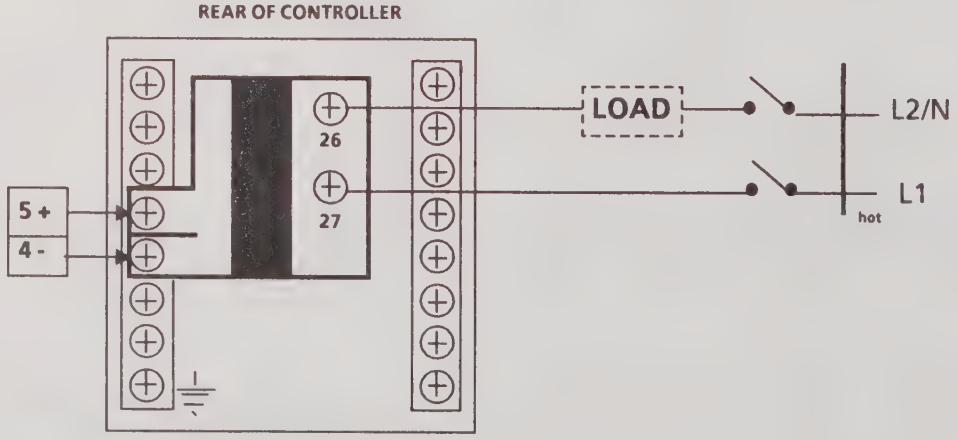


Figure 2-5 Solid State Relay Output Wiring

ALARM AND CONTROL RELAY *CAUTION* NOTE

The alarm and control relay output suppression (snubber) circuitry can be extremely critical when controlling processes and maintaining plant safety. The Universal Digital Controller is shipped with a board-mounted R-C suppression circuit. Its purpose is to protect the relay contacts from arcing due to high energy spikes. These spikes could occur when driving highly inductive loads and fast cycle-time processes. However, in certain AC powered, external solid state relays with very high input impedance, an undesirable leakage current can flow in the R-C suppression circuit and cause a voltage across the external load. This prevents deactivation of your external device (such as a Solid State relay) even though our display and internal relay are functioning correctly.

The fix, as shown in the figure below, is to open the correct R-C circuit by cutting one of the capacitor leads. This is acceptable because if the above problem occurred, the suppression circuit was not needed. Opening the circuit eliminates any leakage current flow and allows the external relay to function normally.

1. To remove the chassis, loosen the screw on the front, and pull the chassis out of the case.
2. Open the desired circuit by cutting the capacitor lead.
3. Return the chassis to the case. Make sure it slides under the guide clip in the bottom of the case.

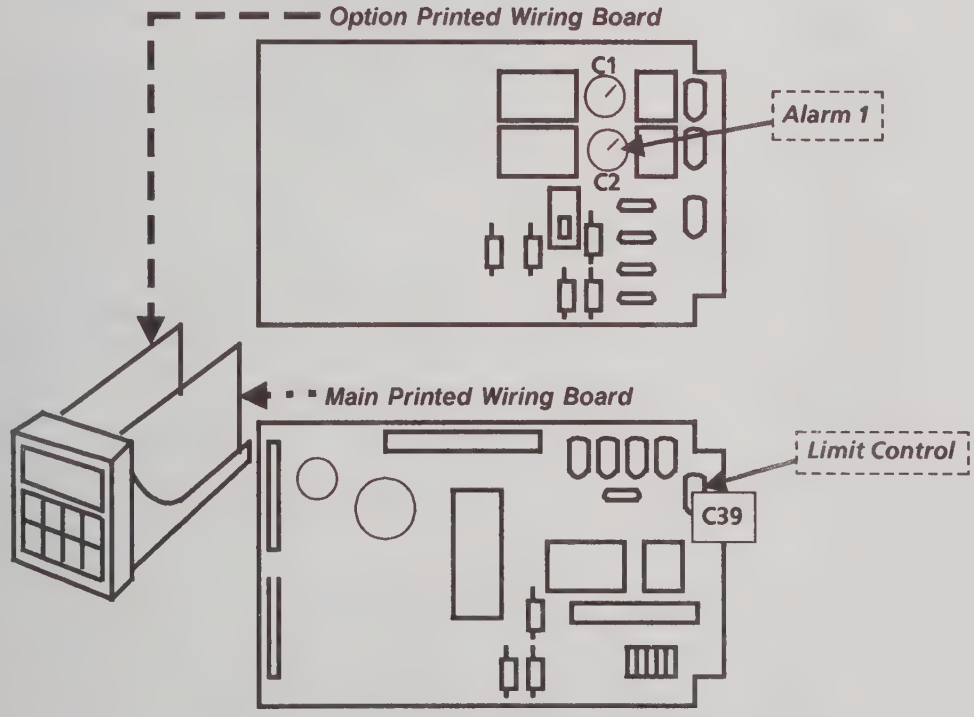


Figure 2-6 RC Circuit Capacitors

SOFTWARE CONFIGURATION

Introduction

Software configuration is a dedicated operation where you use straightforward keystroke sequences to select and establish (configure) pertinent Limit Controller data best suited for your specific application.

Prompts

To assist you in this process, there are prompts which appear in the upper and lower displays (see Figure 3-1). These prompts let you know what group of configuration data you are working with and also, the specific parameters associated with each group. Figure 3-2 gives you an overview of these prompts. As you can see, the configuration data is divided into 5 main Set-Up groups plus *Calibration* and *Read*.

LOCK
LIMIT
INPUT 1
OPTIONS
ALARM 1

Within each of these groups are function prompts of associated parameters.

NOTE: This manual explains all the prompts that can appear in the Mini-Pro Limit Controller. Some of the prompts won't apply to your specific Limit Controller and therefore will not appear.

Key Error

When a key is pressed and the prompt **"KEY ERROR"** appears in the lower display, it will be for either of the following reasons:

- Parameter not available
- Not in Set-Up mode, press **[SET UP]** first

How to Get Started

- Read the procedure (page 3-3) for accessing the groups and the function parameters within each group to become familiar with the key sequences.
- Read the "Configuration Tips" on page 3-3, then start to configure the Limit Controller for your application. The groups and parameters are all listed on page 3-4, along with the selections and range of setting available for each.
- If you need a detailed explanation of any Set-Up or Function prompt listed in this section, go to Section 8 - Appendix A.
- Record your selections on the configuration record sheet (page 3-9) so you'll have a record of how you've configured the Limit Controller.

Figure 3-1 is a view of the operator Interface with which you'll be working.

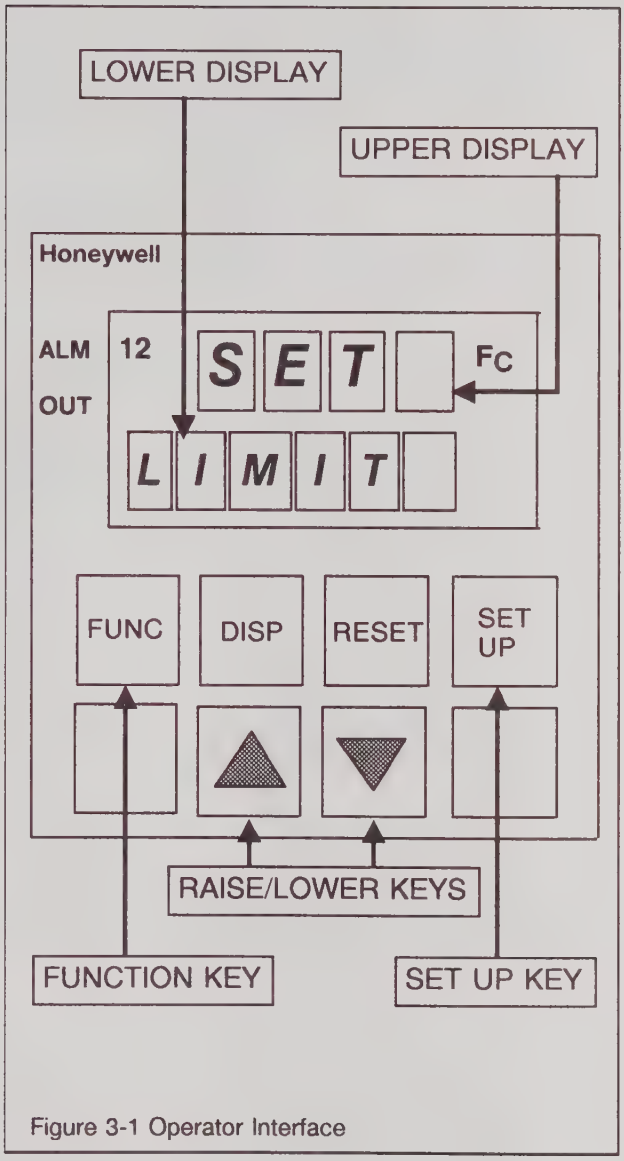


Figure 3-1 Operator Interface

PROMPT HIERARCHY

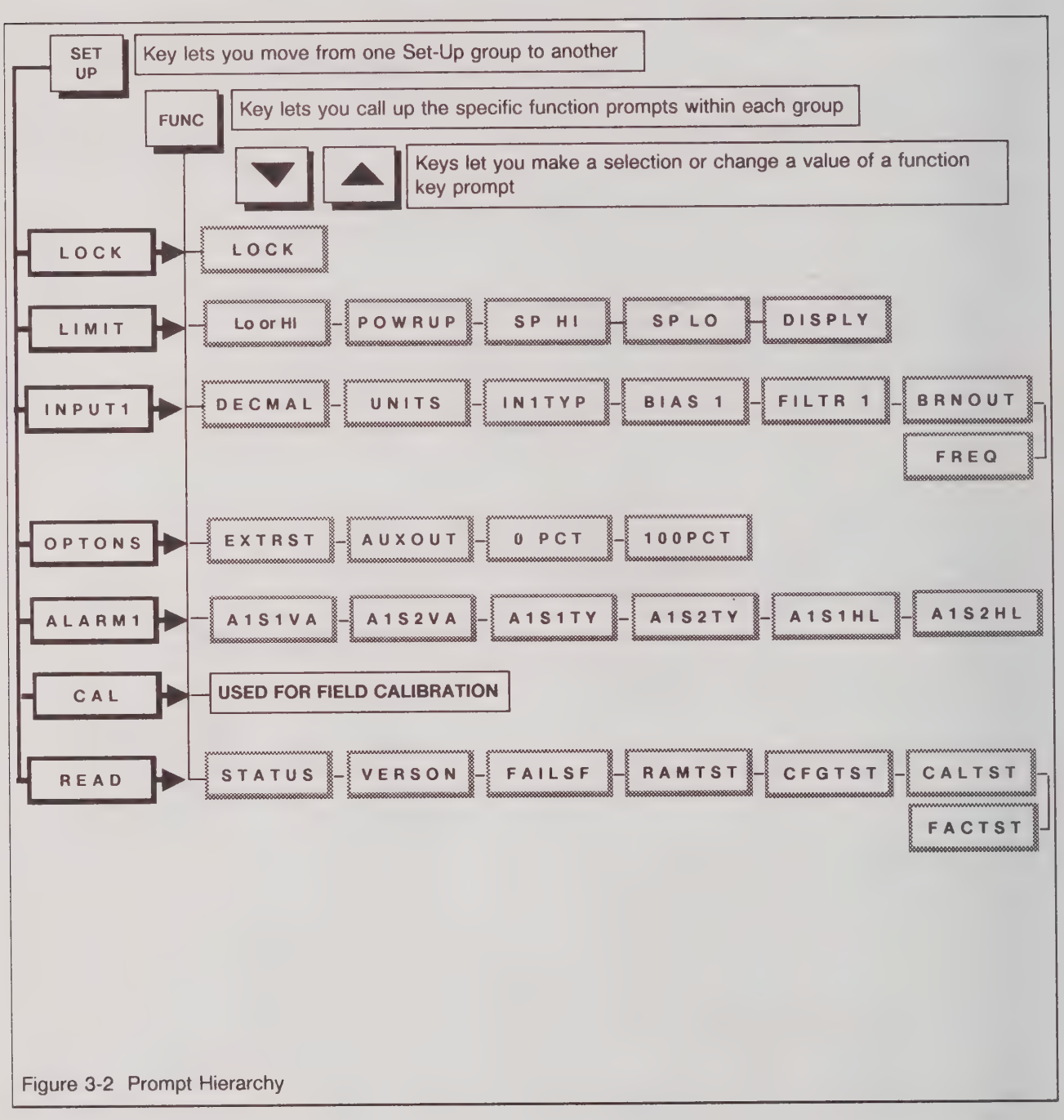


Figure 3-2 Prompt Hierarchy

SOFTWARE CONFIGURATION (continued)

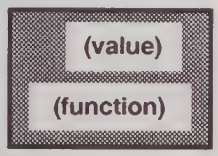
How to Call Up and Change a Configuration Parameter

A list of how the Limit Controller was configured at the factory "Factory Settings"appears on page 3-9. If you want to change any of these selections or values, follow the procedure listed below. This procedure tells you what keys to press so you can effectively use the prompts to start configuring your Limit Controller.

How to Select a Set-Up Group
Press the **[SET UP]** key. You will see **SET** in the upper display to let you know you are in the Set-Up mode and a SET-UP group title is being displayed in the lower display. **LOCK (Lockout)** is first. Successive presses of the **[SET-UP]** key will sequentially display the other Set-Up groups as shown in the prompt hierarchy (page 3-2).

Note 1: Stop at the group you want to configure then go to ***"How to Select a Function"*** for the parameters within that group.

How to Select a Function
As shown in the prompt hierarchy, each of the groups listed contain specific prompts which deal with functions that are pertinent to that particular group. Press the **[FUNC]** key, you will see the individual function prompts for each group and the current value or selection. Successive presses of the **[FUNC]** key will sequencially display all the functions and their values or selections for that group.



NOTE 2: Stop at the function you want to configure, then go to "How to change a value or selection".

How to Change Value or Selection
Press the **[RAISE/LOWER]** key to change the value or selection in the upper display.
If the display blinks, you are trying to select an unacceptable entry or the LOCKOUT is preventing changes.

How to Restore the Original Value or Selection
When you change the value or selection of a parameter while in ***SET UP*** mode and decide not to enter it, press the **[RESET]** key once. The original value or selection will be recalled.

How to Enter a Value or Selection
Press the **[FUNC]** , **[SET UP]**, or **[DISP]** key. The value or selection will be entered into memory.

How to Exit Configuration
Press the **[DISP]** key to exit from configuration and return to normal operation.

Configuration Tips

Listed below are a few procedures that will help you to easily and quickly accomplish the tasks at which you'll be working when you configure the Limit Controller.

Scrolling
To get to a SET-UP group or FUNCTION parameter quickly, hold **[SET UP]** or **[FUNC]** key in. The display will scroll through the parameters.

Changing Values Quickly
When you press the **[RAISE/LOWER]** keys to change a number, the least significant digit increments and decrements. However, if you momentarily press the opposite key while holding one of these two keys, the next significant digit begins to increment and decrement and each additional tap of the "opposite Key" will move the scrolling digit one more step to the left. Remember - you must hold in one key while the other is pressed.

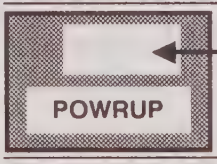
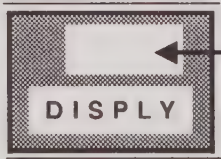
Timing Out from SET-UP
If you are in **SET-UP** mode and don't press any keys for ***one minute***, the controller will time out and revert to the mode and display that was being used prior to entry into SET-UP mode.

Refer to Appendix A for additional data about any prompt you're not sure how to configure.

LOCKOUT PARAMETERS GROUP

PRESS	DISPLAYS	▲▼ SETTING	REMARKS
SET UP	SET LOCK		*In configuration mode,* **"Lock "** *group displayed.*
FUNC		**Selections:NONE** **CAL** **CONF**	***LOCKOUT*** *selections* ***NONE*** *no lockout* ***CAL****ibration locked out* ***CONF****iguration parameters are read only*

LIMIT PARAMETERS GROUP

PRESS	DISPLAYS	▲▼ SETTING	REMARKS
SET UP	SET LIMIT		*In configuration mode,* **"Limit "** *group displayed.*
FUNC		**Selections:Lo** **Hi**	***TYPE OF LIMIT CONTROL*** ***HI*** *= High Limit Control* ***LO*** *= Low Limit Control*
FUNC		**Selections:RST** **NORM**	***POWER UP LOGIC*** ***RST*** *= Controller latching relay will have to be reset at power up* ***NORM*** *= Controller will operate normally in same mode as before power down*
FUNC		**Range: 0 to 100% of input 1 in Engineering Units**	***HIGH SET POINT LIMIT*** *The local set point will automatically adjust itself to be within this limit. Maximum you would ever want to set the set point.*
FUNC		**Range: 0 to 100% of input 1 in Engineering Units**	***LOW SET POINT LIMIT*** *The local set point will automatically adjust itself to be within this limit. Minimum you would ever want to set the set point.*
FUNC		**Selections:SP** **PROC**	***DEFAULT DISPLAY*** ***PROC*** *= Process Variable* ***SP*** *= Set Point*

INPUT 1 PARAMETERS GROUP

PRESS	DISPLAYS	▲▼ SETTING	REMARKS
SET UP	SET INPUT1		*In configuration mode,* **"INPUT 1"** *group displayed.*
FUNC	DECMAL	Selections: 8888 888.8 88.88	***No*** *Decimal place* ***One*** *Decimal place* ***Two*** *Decimal places*
FUNC	UNITS	Selections: F C NONE	*Degrees* ***FAHRENHEIT*** *Degreecs* ***CELSIUS*** ***No*** *Selection*
FUNC	IN1TYP	Selections: b N* 100L E H R E L S J H T H J L T L K H W K L 100H *NiNiMoly Thermocouple	*Select which* ***ACTUATION TYPE*** *you are going to use for Input one.* *See* ***"Installation"*** *to set DIP switches for Input type.* *For Thermocouple Actuations:* *UPSCALE burnout is provided for High Limit Controllers* *DOWNSCALE burnout is provided for Low Limit Controllers*
FUNC	BIAS 1	Range: –10 to +10	***INPUT 1 BIAS*** *Value*
FUNC	FILTR1	Range: 0 to 120 Seconds	***INPUT 1 FILTER*** *- A digital software filter to smooth the Input signal.* *0 = No Filter*
FUNC	BRNOUT	READ ONLY	***BURNOUT*** *UPSCALE for high limit* *DOWNSCALE for low limit*
FUNC	IN1 HI	Not configurable	***INPUT 1 HIGH RANGE VALUE*** *- Not configurable -- used only with linear inputs.*
FUNC	IN1 LO	Not configurable	***INPUT 1 LOW RANGE VALUE*** *- Not configurable -- used only with linear inputs.*

Continued Next Page

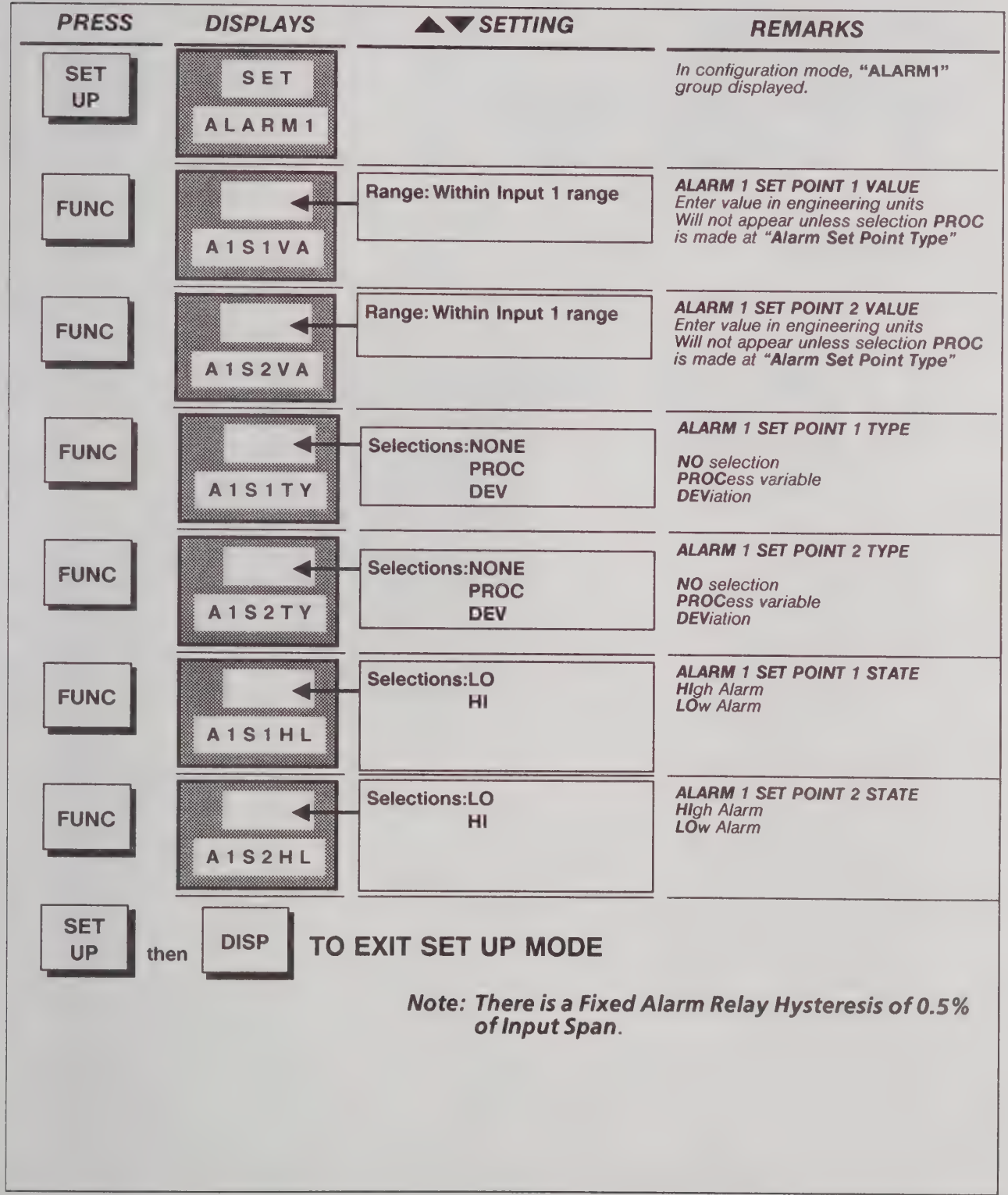
INPUT 1 PARAMETERS (Continued)

PRESS	DISPLAYS	▲▼ SETTING	REMARKS
FUNC	FREQ	Selections:60 50	***POWER FREQUENCY*** *60 Hertz* *50 Hertz* *See **"Installation"** to select jumper position for Operating Voltage.*
SET UP then FUNC or DISP			***SET UP** puts you in next set-up group* ***FUNC** selects the first parameter in the next group* ***DISP** exits set-up mode*

OPTION PARAMETERS GROUP

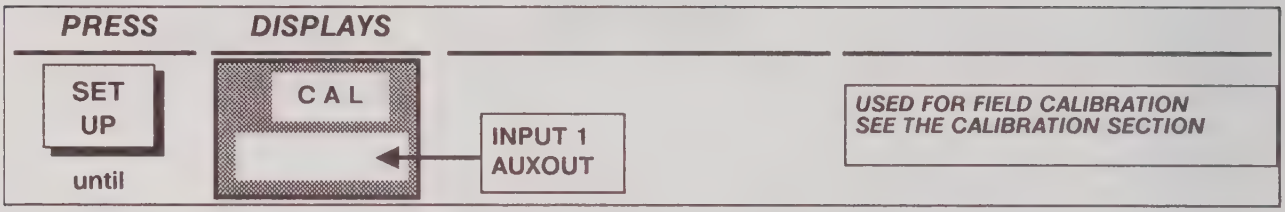
PRESS	DISPLAYS	▲▼ SETTING	REMARKS
SET UP	SET OPTONS		*In configuration mode, **"OPTIONS"** group displayed.*
FUNC	EXTRST	Selections: DIS ENAB	***EXTERNAL RESET(Digital Input)*** ***DIS** = Disabled* ***ENAB** - Enables External Reset. Contact closure resets the latching relay*
FUNC	AUXOUT	Selections:NONE PROC	***AUXILIARY OUTPUT OPTION*** ***NO** selection* ***PROC**ess Variable*
FUNC	0 PCT	Range: WITHIN THE RANGE LIMITS OF INPUT 1	***LOW SCALING FACTOR*** *use a value in engineering units*
FUNC	100PCT	Range: WITHIN THE RANGE LIMITS OF INPUT 1	***HIGH SCALING FACTOR*** *use a value in engineering units*
SET UP then FUNC or DISP			***SET UP** puts you in next set-up group* ***FUNC** selects the first parameter in the next group* ***DISP** exits set-up mode*

ALARM PARAMETERS GROUP

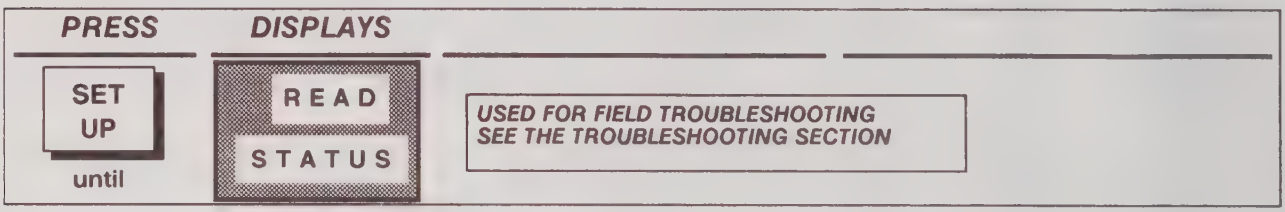


Note: There is a Fixed Alarm Relay Hysteresis of 0.5% of Input Span.

CALIBRATION PARAMETERS GROUP



STATUS GROUP



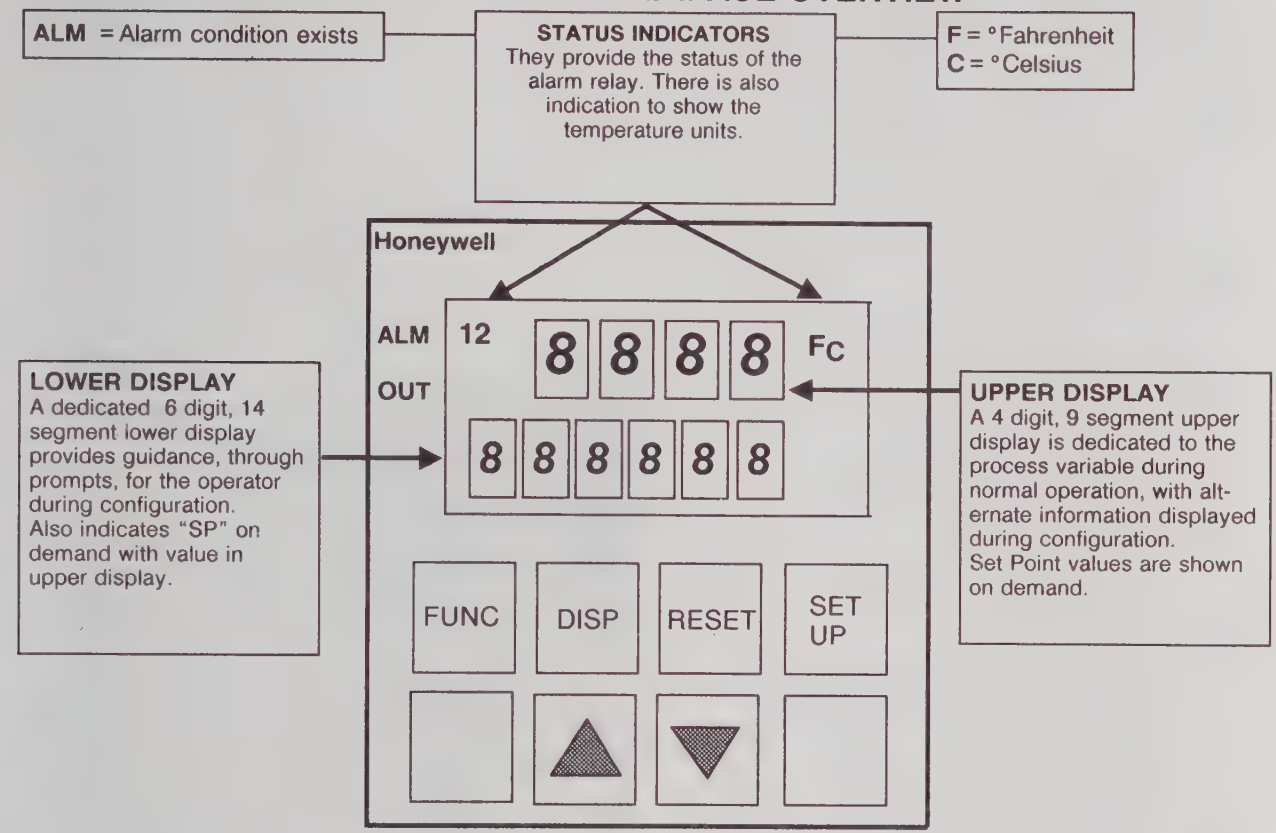
LIMIT CONTROLLER CONFIGURATION RECORD SHEET

GROUP DESCRIPTION	FUNCTION DESCRIPTION	VALUE OR SELECTION	FACTORY SETTING
LOCK	LOCK		CAL
LIMIT	Lo or Hi		
	POWRUP		NORM
	SP HI		1000
	SP LO		0
	DISPLY		PROC
INPUT 1	DECMAL		8888
	UNITS		NONE
	IN1TYP		K H
	IN1 HI		2400
	IN1 LO		0
	BIAS 1		0
	FILTR1		0
	FREQ		60
OPTIONS	EXTRST		NONE*
	AUXOUT		NONE*
	0 PCT		0
	100 PCT		1000
ALARMS	A1S1VA		90
	A1S2VA		10
	A1S1TY		NONE
	A1S2TY		NONE
	A1S1HL		HI
	A1S2HL		LO

*Appears only if model number allows.

← *Configured according to the model ordered*

OPERATOR INTERFACE OVERVIEW


ALM = Alarm condition exists
STATUS INDICATORS
They provide the status of the alarm relay. There is also indication to show the temperature units.
F = °Fahrenheit
C = °Celsius
Honeywell
ALM
OUT
12
8 8 8 8
Fc
8 8 8 8 8 8
LOWER DISPLAY
A dedicated 6 digit, 14 segment lower display provides guidance, through prompts, for the operator during configuration.
Also indicates "SP" on demand with value in upper display.
UPPER DISPLAY
A 4 digit, 9 segment upper display is dedicated to the process variable during normal operation, with alternate information displayed during configuration.
Set Point values are shown on demand.
FUNC
DISP
RESET
SET UP

Key Functions

Six keys enable complete configuration and operation.

FUNC	Selects functions within each configuration SET UP group.		Not used
DISP	Allows viewing of the set point or Process Variable. Returns the controller to normal operation from SET UP mode.	▲	Increases the set point or configuration values.
RESET	Deactivates the latching relay except in Set Up mode. Also used to restore original value or selection when in SET UP mode.	▼	Decreases the set point or configuration values.
SET UP	Scrolls through the configuration groups.		Not used.

Figure 4 - 1 Operator Interface

CHECKING THE CONFIGURATION

Make sure the Limit Controller has been configured to handle your process needs. Refer to "Configuration" Section 3 for prompts and parameters.

- Input Parameters
- Alarm Set Points and type
- Limit control type - High or Low
- External Reset (Contact Input) - Enable or Disable
- Power up Logic - Reset (relay on) or Normal (same as before power down)
- Lockout selection

POWERING THE CONTROLLER

Apply Power

The Mini-Pro Limit Controller runs four background tests to determine the status of the controller:

- *RAM TEST* - checks internal memory
- *CONFIGURATION TEST* - checks the controller's software configuration for inconsistencies
- *CALIBRATION* - check calibration of the controller's configured analog inputs (Input 1) and output (PV Output Voltage)
- *FACTORY CALIBRATION CHECKSUM* - check factory set input constants

If all these Background tests pass, the controller will function in a normal manner without any diagnostic message.

However, if one or more of these tests fail, the controller will go to FAILSAFE (**"FAILSF"** blinking in the lower display). Refer to the "Troubleshooting" section in this manual to identify and correct the problem.

OPERATING PRINCIPLES

The UDC 2000 Mini-Pro Limit Controller accepts signals from such sources as thermocouples (T/Cs), Resistance Temperature Detectors (RTDs), Milliamps, Millivolts, and Volts dc. The equivalent PV signal is compared with the Limit set point. If above (Hi Limit) or below (Lo Limit) a limit output relay is de-energized. When de-energized, the output relay locks out and remains in this state until the PV input signal drops below the high limit set point or rises above the low limit set point, and the controller is reset manually from the front of the controller or through an optional external switch.

MONITORING THE CONTROLLER

The Displays and Indicators

The displays and indicators on the operator interface as shown in figure 4-1 let you see what is happening to your process and how the Limit Controller is responding.

Displays

The Mini-Pro is a single line display device except when in the SET-UP mode or **[DISP]** key is pressed or limit has been reached.

MONITORING THE CONTROLLER(cont..)

The ***UPPER*** display area has 4 digits dedicated to the value of the process variable during normal operation with alternate information displayed on demand during configuration. Set Point values can also be shown on demand using **[DISP]** key.

The ***LOWER*** display area has 6 digits which are normally blank but indicate Set Point prompts upon request. It also provides alpha-numeric prompts during configuration as well as diagnostic and error messages when appropriate.

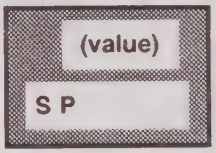
Indicators

The annunciator displays, as shown in figure 4-1, give the following indications:

ALM 1 = Alarm Relay ON/OFF status
F or C = Temperature Units (°F or °C)

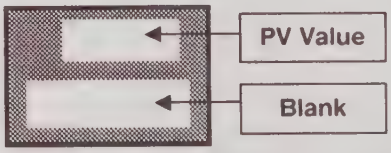
The [DISP] key

Press the **[DISP]** to show the set point or PV in the upper display, depending on which has been configured as the default display:



Local Set Point 1

or



You can press the **[RAISE/LOWER]** keys to change only the ***Set Point*** value shown in the upper display.

Timing out from Upper Display

If it configured as the default display variable, the normal Process Variable display will automatically return in the upper display if the **[DISP]** key is not pressed for 60 seconds.

The **[DISP]** key is also used to return to normal control from SET-UP mode.

The [RAISE/LOWER] key

When you press the **[RAISE/LOWER]** keys to change a number, the least significant digit increments or decrements. However, if you momentarily press the opposite key while holding one of these two keys, the next significant digit begins to increment or decrement and each additional tap of the "opposite Key" will move the scrolling digit one more step to the left.

Remember - you must hold in one key while the other is pressed.

MONITORING THE CONTROLLER(cont..)

Key Error

When a key is pressed and the prompt "KEY ERR" appears in the lower display. it will be for one of the following reasons:

- Parameter not available
- Not in SET-UP mode. Press **[SET UP]** key first.

Diagnostic Error Messages

The Mini-Pro performs additional background tests to verify data and memory integrity. If there is a malfunction, an error message will be displayed. In the case of more than one, the one with the highest priority will appear on the lower display.

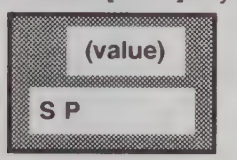
LOWER DISPLAY PROMPT	*CONDITION*
E FAIL	Unable to write to non-volatile memory
FAILSF	Failsafe
IN1FL	Two consecutive failures of Input 1 integration
IN1 RNG	Input 1 out-of-range
PV LIM	PV ± 10% out-of-range

IF ANY OF THESE ERROR MESSAGES OCCUR, REFER TO THE TROUBLESHOOTING SECTION IN THIS MANUAL.

OPERATING THE CONTROLLER

Enter a Set Point Value

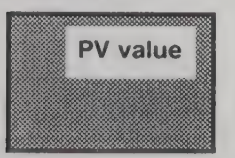
Press the **[DISP]** key until you see



Press the **[RAISE/LOWER]** keys to adjust the Local Set Point to the value you want.
The display "BLINKS" if you attempt to enter a set point value beyond the high and low set point limits.

Return to PV Display

Press the **[DISP]** key. You will see



or

Whatever has been configured as the default display.

OPERATING THE CONTROLLER (continued)

High and Low Limit Indication

When the high or low limit is exceeded, the lower display indicates the word "LIMIT" (blinking). This will continue until you reset the latching relay using the [RESET] key or through the Optional External Reset feature.

How to Reset the Latching Relay

NOTE: The latching relay cannot be reset until the PV input signal drops below the high set point or rises above the low set point value.

Press [RESET] key or make contact closure of an external switch if the Contact Input option is present.

Using Contact Input Option (External Reset)

The Contact Input Option detects the state of external contacts. On contact closure, the controller will reset the latching relay if the controller has External Reset enabled. To allow External Reset (Contact Input):

Press the **[SET UP]** key until you see

Press the **[FUNC]** key until you see

Press the **[RAISE/LOWER]** keys to select ENAB in the upper display.

OPERATING THE CONTROLLER(CONT..)

Changing the Alarm Set Points

The Alarm Set Point Values can be changed for each of the two alarm set points.

Press the **[SET UP]** key until you see

Press the **[FUNC]** key until you see

Range: Within Input 1 range

This is the Alarm 1 Set Point 1 Value.
Press the **[RAISE/LOWER]** keys to change the value in the upper display.

Press the **[FUNC]** key 1 more time and repeat the procedure to set the other alarm set point value.

A 1 S 2 V A

REFER TO THE CONFIGURATION SECTION OF THIS MANUAL TO DISPLAY OR CHANGE THESE ASSOCIATED ALARM PARAMETERS

SET UP GROUP PROMPT	*FUNCTION PROMPT*	*PARAMETER*
ALARMS	**A1S1TY** **A1S2TY**	Alarm Set Point type
	A1S1HL **A1S2HL**	Alarm Set Point State - High or Low

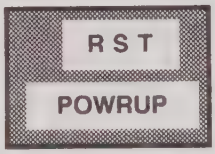
A jumper selection configures the relay contacts for Normally Open (open with power off) or Normally Closed. Refer to the Installation Section under "Preliminary Checks" for Alarm relay contact information chart and jumper placement.

Press the **[DISP]** key to return to normal control.

OPERATING THE CONTROLLER(CONT..)

Power Up Logic

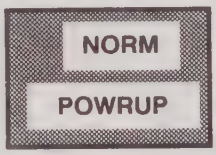
Configurable Power Up Logic lets you select the latching output relay to require "RESET" or to provide normal operation at power up.
If power to the Limit Controller fails and power is reapplied, the controller goes through power up tests then starts in one of the following configurabnle conditions:
If you configured



At Set Up group "LIMIT"

- The lower display will blink "LIMIT" at power up. This will require reset via the [RESET] key or external switch to obtain normal operation.

If you configured



At Set Up group "LIMIT"

- The display and Limit Controller will function normally at power up, i.e. no reset of the latching relay is required *unless a limit has been exceeded. If the limit was latched when power went down, the unit will be in limit at power up.*

Refer to Configuration section under *SET UP* prompt "LIMIT" and make your selection at *FUNCTION* prompt "POWRUP".

CALIBRATION

SECTION 5

This section has two parts, **Input Calibration** and **Output Calibration**
Each part has the following sub-headings:

- ***Introduction*** - when calibration is required.
- ***Preliminary Procedures*** - disconnecting the field wiring, setting internal DIP switches, etc.
- ***Equipment Needed*** - what you need to do the calibration.
- ***Set Up*** - how to set-up the controller for the calibration procedure, i.e. terminal connections, etc.
- ***Calibration Procedures*** - how to do the calibration.

INPUT CALIBRATION - describes the field calibration procedures for Input 1.

- ***Input 1*** - can be calibrated for a variety of thermocouples and RTD ranges.
  You select which type of input you will be calibrating by SETTING A DIP SWITCH inside the chassis on the Main Printed Wiring board, then connect a calibrating device as described in SET UP and following the PROCEDURE for Input 1.

OUTPUT CALIBRATION - describes the field calibration procedures for PV (Auxiliary) Output.

- ***PV (Auxiliary) Output*** - can be calibrated for a range of 0 to 5 Volts or 1 to 5 Volts by connecting a calibrating device as described in SET UP and following the PROCEDURE.

INPUT CALIBRATION

Introduction

This part describes the field calibration procedures for input 1. However, this procedure should only be implemented if the factory calibration of the desired input range is not within specifications. Note that every Mini-Pro Limit Controller contains all input ranges fully factory calibrated and ready for configuration to the range by the user. It should not be necessary to recalibrate the controller.

Note also, that the field calibration will be lost if a change in input type configuration is implemented at a later time. The input will revert to whatever is stored in memory.

Minimum and Maximum Range Values

Calibrate the Mini-Pro controller to the minimum (0%) and maximum (100%) range values for your particular sensor.
Select the voltage or resistance equivalent for 0% and 100% range values from Table 5-1 on page 5-2.
Use these values when calibrating the input.

TABLE 5-1 -- Voltage and Resistance Equivalents for 0% and 100% Range Values

Sensor Type	PV Input Range		Range Value	
	°F	°C	0%	100%
B T/C	150 to 3300	66 to 1815	0.009 mV	13.763 mV
E T/C	–100 to 1832	–73 to 1000	–3.976 mV	76.358 mV
E (low) T/C	–100 to 1100	–73 to 593	–3.976 mV	44.547 mV
J (T/C)	0 to 1600	–18 to 871	–0.885 mV	50.059 mV
J (low) T/C	0 to 900	–18 to 482	–0.885 mV	26.396 mV
K T/C	0 to 2400	–18 to 1316	–0.692 mV	52.939 mV
K (low) T/C	–20 to 1000	–29 to 538	–1.114 mV	22.251 mV
NiNiMoly T/C	32 to 2500	0 to 1371	–0.001 mV	71.330 mV
R T/C	0 to 3100	–18 to 1704	–0.089 mV	20.275 mV
S T/C	0 to 3100	–18 to 1704	–0.092 mV	17.993 mV
T T/C	–300 to 700	–184 to 371	–5.341 mV	19.095 mV
T (low) T/C	–80 to 500	–63 to 260	–2.225 mV	12.572 mV
W_5W_{26} T/C	0 to 4200	–18 to 2316	–0.234 mV	37.066 mV
RTD **IEC alpha = 0.00385** 100 ohms	–300 to 900	–184 to 482	25.18 ohms	274.96 ohms
	0 to 300	–18 to 149	93.03 ohms	156.90 ohms

INPUT CALIBRATION (continued)

Preliminary Procedures

Disconnect Field Wiring
Tag and disconnect any field wiring connected to the input terminals on the rear of the controller. (See Figure 5-1)

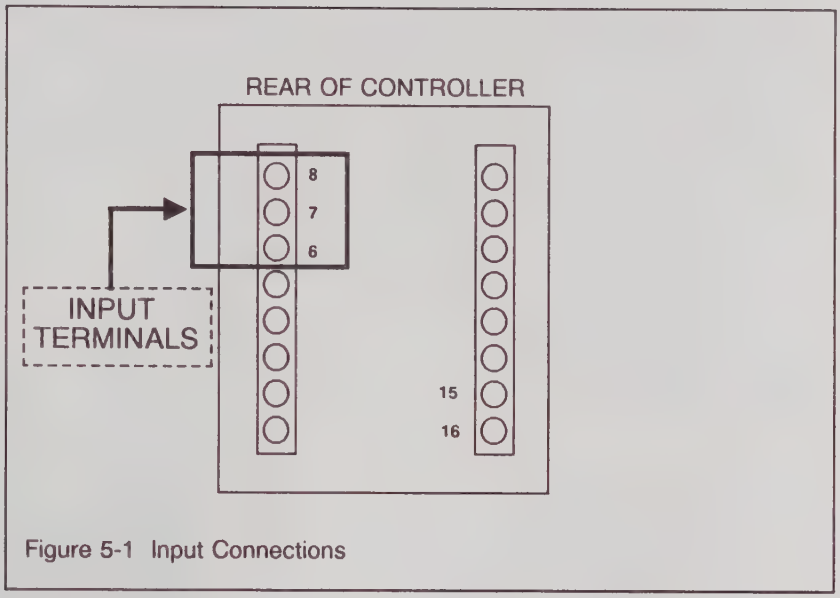


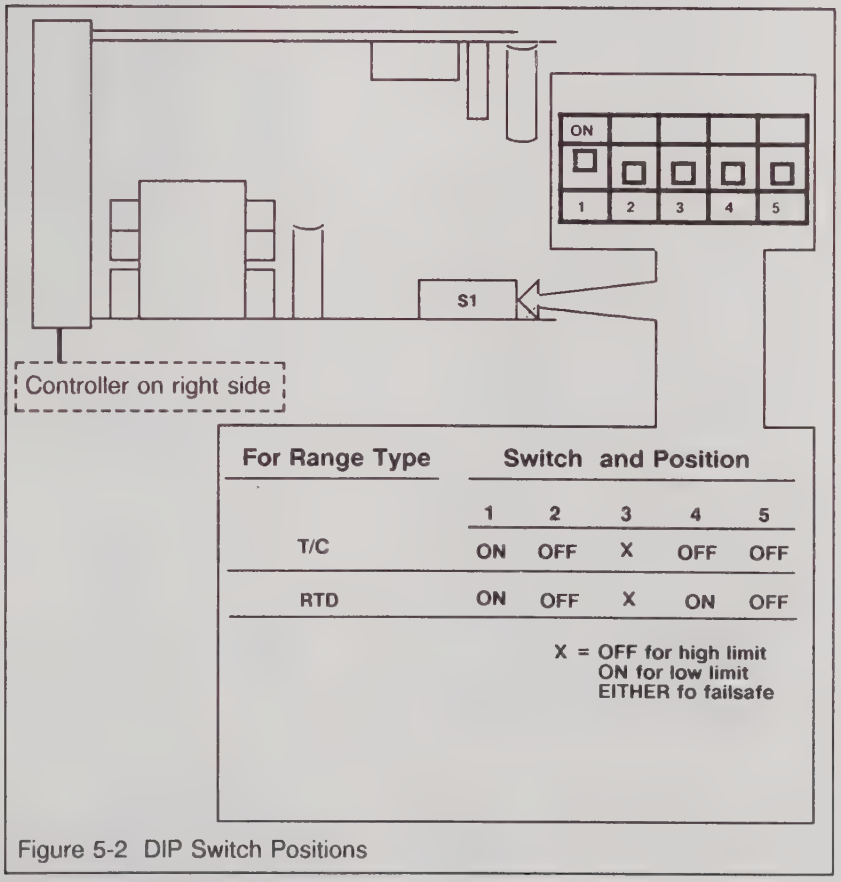
Figure 5-1 Input Connections

Set the DIP Switches for the Input
Before you calibrate the Input, you must check an internal DIP switch to make sure the switches are set for the correct Input type;

Thermocouples,
RTD

Procedure

1. Loosen the screw on the front of the controller and pull the chassis out of the case. Lay the chassis on the right side.
2. The switches are located at the rear top position on the main assembly board. (See Figure 5-2)
3. Set the switches for the range type desired according to the table in figure 5-2.



For Range Type	Switch and Position				
	1	2	3	4	5
T/C	ON	OFF	X	OFF	OFF
RTD	ON	OFF	X	ON	OFF

X = OFF for high limit
ON for low limit
EITHER fo failsafe

Figure 5-2 DIP Switch Positions

INPUT CALIBRATION (continued)

Equipment Needed

- Screwdriver

THERMOCOUPLE INPUTS (ICE BATH)

- A calibrating device with ±0.02% accuracy for use as a signal source.
- Thermocouple extension wire that corresponds with the type of thermocouple that will be used with the controller input.
- Two insulated copper leads for connecting the thermocouple extension wire from the ice baths to the mV source.
- Two containers of crushed ice.

RTD (RESISTANCE THERMOMETER DEVICE)

- A Decade Box, with ±0.02% accuracy, capable of providing stepped resolution of .01 Ohm.
- Three insulated copper leads for connecting the Decade Box to the controller.

Set-Up (SEE FIGURE 5-3)

THERMOCOUPLE INPUTS (ICE BATH)

- Connect the copper leads to the calibrator.
- Connect a length of thermocouple wire to the end of each copper wire and insert each junction point into an ice bath.
- Connect the thermocouple extension wire to the terminals for input 1.
- Measure and record temperature at the rear of the case.

RTD

- Connect the copper leads from the calibrator to the input 1 terminals as shown in figure 5-3.
- Place current source at zero before switching on.
- Do not switch current sources on/off while connected to the UDC 2000 input.

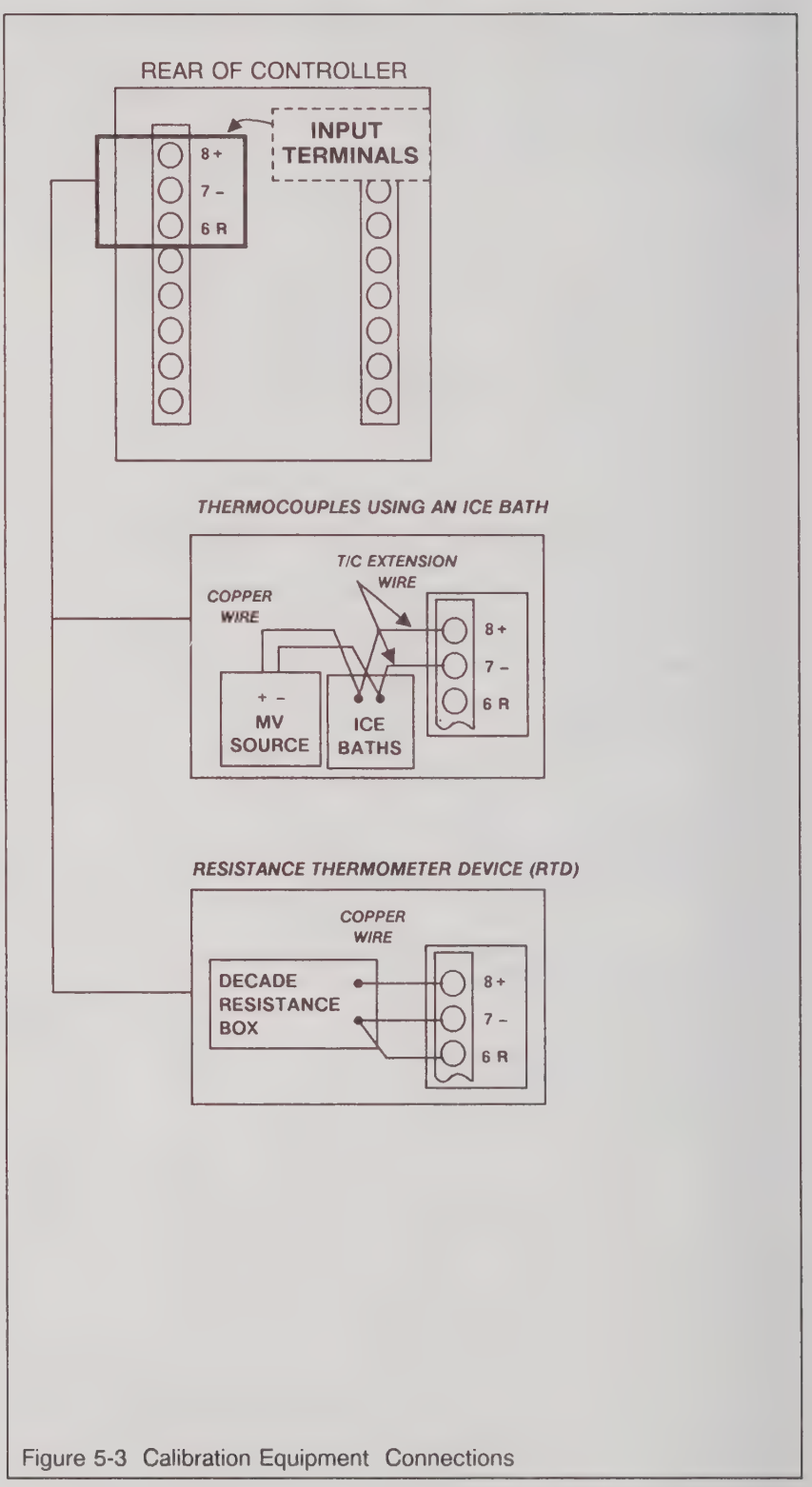


Figure 5-3 Calibration Equipment Connections

INPUT CALIBRATION (continued)

INPUT CALIBRATION PROCEDURE

Apply power and let the controller warm up for 15 minutes before you calibrate.
CAUTION: For Linear inputs, avoid step changes in inputs. Vary smoothly from initial value to the final 100% value.
Please read "**SET UP**" on previous page before beginning the procedure.

See Table 5-1 on page 5-2 for Voltage vs Resistance equivalent.

Make sure Set Up configuration prompt "LOCK" is set to "NONE".

PROCEDURE	*PRESS*	*DISPLAYS*	*ACTION*
Enter Calibration Mode	SET UP	CAL / INPUT1	Go to next key press.
	FUNC	DIS / CALIN1	Go to next key press to enable INPUT 1 calibration. *Note: After completion of the calibration sequence, the controller automatically reverts to disable.*
	▲	BEGN / CALIN1	This begins the calibration procedure, Go to next step.
Calibrate 0%	FUNC	APLY / IN1ZRO	Adjust your calibrating device to an output signal equal to the 0% range value for your particular input sensor. (table 5-1) Wait 30 seconds, then go to next step.
Calibrate 100%	FUNC	APLY / IN1SPN	Adjust your calibrating device to an output signal equal to the 100% range value for your particular input sensor. Wait 30 seconds, then go to next step if the input is configured for thermocouple; otherwise, go to "*Exit Calibration Mode*".
Check the Cold Junction Temperature	FUNC	(value) / CJTEMP	Compare the measured value to the value in the upper display which is in tenths of a degree. It is the current reading of the temperature as measured at the thermocouple terminals and recognized by the controller. You can change this value, if it is in error, using ▲▼ keys.
Exit Calibration Mode	FUNC *then* DISP	pv value	This stores the calibration constants and exits the calibration mode.

OUTPUT CALIBRATION PROCEDURE

PV (AUXILIARY) OUTPUT

Introduction

Calibrate the controller so that the output provides the proper amount of voltage over the desired range. The controller can provide a Voltage output range of from 0 to 5 Volts and can be calibrated at 0 Volt for 0% of output and 5 Volts for 100% of output or any other values between 0 and 5 Volts.

Preliminary Procedures

- Tag and disconnect the field wiring at the rear of the controller from terminals 13 and 14. (See Figure 5-4.)
- Check that jumper (AUXOUT) is positioned per figure 2-1.

Equipment needed

- A calibrating device with whatever accuracy is necessary, capable of measuring 0 to 5 Volts.

Set-Up

- Connect a calibrating device across terminals 13 and 14 (see Figure 5-4).
- Apply the power and allow the controller to warm up for 15 minutes before you calibrate.

Follow the procedure on the next page.

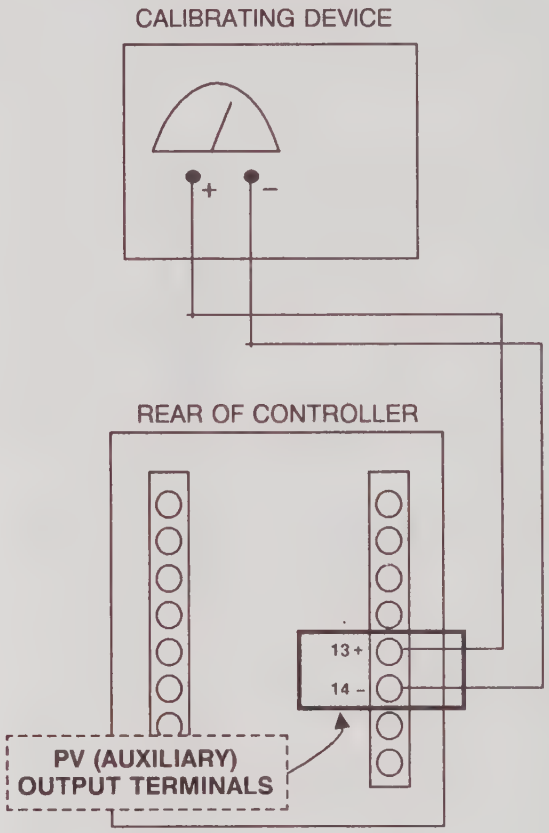


Figure 5-4 Calibration Equipment Connections

OUTPUT CALIBRATION (continued)

AUXILIARY OUTPUT CALIBRATION PROCEDURE

Make sure

Set Up configuration prompt "LOCK" is set to "NONE".
Function prompt AUXOUT" under Set Up prompt "OPTONS" is set to "PROC"
External Reset is disabled.

PROCEDURE	*PRESS*	*DISPLAYS*	*ACTION*
Enter Calibration Mode	SET UP	CAL AUXOUT	Go to next step.
Calibrate 0%	FUNC	(value) ZROVAL	Go to next step.
	▲ or ▼ *until*		the desired 0% output is read on the voltmeter.
Calibrate 100%	FUNC	(value) SPNVAL	This stores the minimum value and gives you the display shown. Go to the next key press.
	▲ or ▼ *until*		the desired 100% (span) output is read on the voltmeter.
Exit Calibration Mode	FUNC *then* DISP	(pv value)	This stores the span value and exits the calibration mode.

TROUBLESHOOTING/SERVICE SECTION 6

INTRODUCTION

Instrument performance can be adversely affected by installation and application problems as well as hardware problems. We recommend that you investigate the problems in the following order:

- **Installation Related Problems** - Read the Installation Section in this manual to make sure the Mini-Pro has been properly installed. The Installation section provides information on protection against electrical noise, connecting external equipment to the controller, and shielding and routing external wiring.
  IMPORTANT: System noise induced into the controller will result in diagnostic error messages recurring. If the diagnostic error message can be cleared, it indicates a "soft" failure and is probably noise related.
  If system noise is suspected, completely isolate the controller from all field wiring. Use calibration sources to simulate PV and check all controller functions i.e. Output, Alarms, etc.
- **Application Related Problems** - Review the application of the controller; then, if necessary, direct your questions to the local sales office.
- **Hardware and Software Related Problems** Use the troubleshooting error message prompts and controller failure symptoms to identify typical failures which may occur in the controller. Follow the troubleshooting procedures to correct them.

CONTROLLER FAILURE INDICATIONS

Error Messages

The Mini-Pro runs background tests during normal operation. If a problem with the Background tests occurs, an error message will be displayed on the operator interface. Table 6-1 shows you the error message, what the failure is, and how to correct the problem.

Other Failure Symptoms

Other failure symptoms may occur that deal with the Power, Output, or Alarms. Refer to the controller failure symptoms in table 6-3 to determine what is wrong and the troubleshooting procedure to use to correct the problem.

Check Installation

If a set of symptoms still persists, refer to the Installation section of this manual and ensure proper installation and proper use of the controller in the system.

CUSTOMER SUPPORT

If you cannot solve the problem using the trouble-shooting procedures listed in this section, get model and serial number and

Call Customer Support Phone Number

1-800-423-9883

If it is determined that a hardware problem exists and the controller is within the two year warranty, a replacement controller will be shipped with instructions for returning the defective unit.

ERROR MESSAGES

The Mini-Pro Limit Controller performs on-going background tests to verify data and memory integrity. If there is a malfunction, an error message will be displayed (blinking) in the lower display.
In the case of more than one simultaneous malfunction, only the one with the highest priority will appear in the lower display.

Table 6-1 below shows these error messages, the reason for the failure, and how to correct the problem.

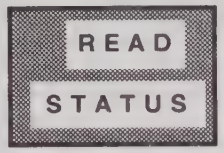
TABLE 6-1 BACKGROUND TESTS ERROR PROMPTS

Lower Display Prompt	Reason For Failure	How to Correct the Problem
E FAIL	Unable to write to non-volatile memory. Anytime you change a parameter and it is not accepted, you will see **E FAIL**.	1. Check the accuracy of the parameter and re-enter.
FAILSF	This error message shows whenever the controller goes into failsafe mode of operation. This will happen if: • RAM Test failed • Configuration Test Failed • Calibration Test Failed • Factory Calibration Checksum Failed	1. Run through **STATUS** check to determine the reason for the failure: Press [SET UP] until **READ** appears in the lower display. Press [FUNC] to see which tests Pass or Fail. **RAMTST CFGTST CALTST FACTST** 2. Correct according to the recommendations given for a particular failure in Table 6-2.
IN1FAIL	Two consecutive failures of input one integration, i.e. cannot make analog to digital conversion	1. Make sure the actuation is configured correctly. See Configuration Section 3. 2. Make sure the input is correct. 3. Check for gross overranging.
IN1RNG	Input 1 - out of range. The process is outside the range limits. NOTE: If the range goes outside the criteria listed above, the controller will go to the failsafe output value.	1. Make sure the range and actuation are configured properly. 2. Check the input source. 3. Go to the Configuration Section and change the input type to a different type. Enter it, loop through STATUS test prompts then return input to original. 4. Check the Input type switch placement. Refer to "Preliminary Checks" in Installation Section 2. 5. Field calibrate - See Calibration section 5.
PV LIM	PV Out-of-Range The result of the formula shown below is beyond the range of the PV PV = IN1 + IN1 BIAS	1. Make sure the input signal is correct. 2. Make sure the Bias setting is correct. 3. To recheck the calibration, use Ratio 1.0 and Bias 0.0

STATUS TESTS

When required, the results of these STATUS tests can be checked to determine the reason the controller has gone to failsafe.

Press the **[SET UP]** key until you see



Press **[FUNC]** key until you see

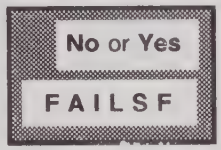


TABLE 6-2 STATUS TESTS

Lower Display Prompt	Definition	Upper Display Prompt	Reason for Failure	How to Correct the Problem
FAILSF	Failsafe Fault	NO YES	No Failure Burnout configured for none and input fails RAMTST failed CFGTST failed CALTST failed FACTST failed	1. Step through the rest of the STATUS check to identify the particular failure. Press **[FUNC]** key.
RAMTST	RAM Test	PASS FAIL	No Failure RAM Failure	1. Power cycle to see if the error clears.
CFGTST	Configuration Checksum	PASS FAIL	No Failure Configuration data in the controller in error.	1. Step through the STATUS tests, the controller will calculate the checksum. 2. Check all the configuration prompts for accuracy. See Configuration Section 3.
CALTST	Working Calibration Checksum	PASS FAIL	No Failure Working calibration constants in the controller in error.	1. If the controller has not been field calibrated, see the configuration section and change the input type to a different type. Enter it, loop through all the STATUS tests then return input type to the original. 2. If the controller has been field calibrated, recalibrate the controller.
FACTST	Factory Calibration Checksum	PASS FAIL	No Failure Factory set input constants in the controller are in error.	1. Cycle through STATUS to clear the error. 2. Check the calibration - make sure 0 and 100% are the correct values. See Calibration Section 5. 3. Recalibrate. If step 1 is unsatisfactory, always do step 3 - See Calibration Section 5.

CONTROLLER FAILURE SYMPTOMS

In addition to the error message prompts there are failure symptoms that can be identified by noting how the controller's displays, indicators, and controller functions are reacting.
Compare your symptoms with those shown in Table 6-3 and refer to the troubleshooting procedure indicated to correct the problem.

If a set of symptoms or prompts other than the one you started with appears while troubleshooting, re-evaluate the symptoms. This may lead to a different troubleshooting procedure.
If the symptoms still persist, refer to the Installation Section in this manual to ensure proper installation and proper use of the controller in your system.

EQUIPMENT NEEDED TO FOLLOW TROUBLESHOOTING PROCEDURES

- DC Milliammeter XX.XX mAdc
- Calibration Sources - T/C, RTD.
- Voltmeter

The troubleshooting procedures begin on the next page.

TABLE 6-3 CONTROLLER FAILURE SYMPTOMS

Upper Display	Lower Display	Indicators	Controller Output	Probable Cause	Troubleshooting Procedure
Blank	Blank	Off	None	Power Failure	1
OK	Lower Display Disagrees with Latching Output Relay Function	OK	Latching Output Relay Function Disagrees with Lower Display	Latching Output Relay	2
OK	OK	OK	External Alarm Function Does Not Operate Properly	Malfunction in Alarm Output	3

CONTROLLER FAILURE SYMPTOMS TROUBLESHOOTING PROCEDURES

PROCEDURE 1: TROUBLESHOOTING POWER FAILURE

What to Do	How to do it or where to find the Data
1. Check the AC line Voltage.	1. Use a Voltmeter to measure the AC Voltage across terminals L1 and L2 on the rear terminal panel of the controller.
2. Make sure the chassis plugs into the rear of the case properly.	2. Withdrawl the chassis from the case and visually inspect the main printed wiring board for damage.
3. Check the Voltage selection.	3. See if the J1 connector on the main printed wiring board is in the proper position for the voltage being used. See "Preliminary Checks" in the Installation Section.
4. Check the system for brown-outs, heavy load switching, etc.; and conformance to installation instructions.	4. Refer to the Installation Section.

PROCEDURE 2: TROUBLESHOOTING LATCHING OUTPUT RELAY FAILURE

What to Do	How to do it or where to find the Data
1. Make sure all the configurable data for the Limit Controller is correct	1. See the Configuration Section in this manual to check the configuration data and to reconfigure if necessary.
2. Check that the latching relay actuates properly	2. Move the set point above or below the PV value depending on the type of Limit control configured. Listen for the click of the relay as the set point is moved above or below the PV
3. Check the latching output relay jumper position (NO or NC)	3. See the Installation section for Relay contact information.

PROCEDURE 3: TROUBLESHOOTING ALARM RELAY OUTPUT FAILURE

What to Do	How to do it or where to find the Data
1. Check the alarm configuration data. If it is correct, check the field wiring. Reconfigure if necessary.	1. See the Configuration Section.
2. Check the alarm relay jumper position.	2. See the Installation Section for jumper placement and contact information.
3. Check that the applicable alarm relay actuates properly depending on what you have set at "ALARMS" group prompt "AxSxTY". If it does, check the field wiring.	3. If the alarm type is set for PROC (process varaible), press **[DISP]** to display SP. Vary the alarm set point around the PV creating a deviation value and listen for a click from the relay as the SP moves in either direction and note that the indicator ALM1 lights

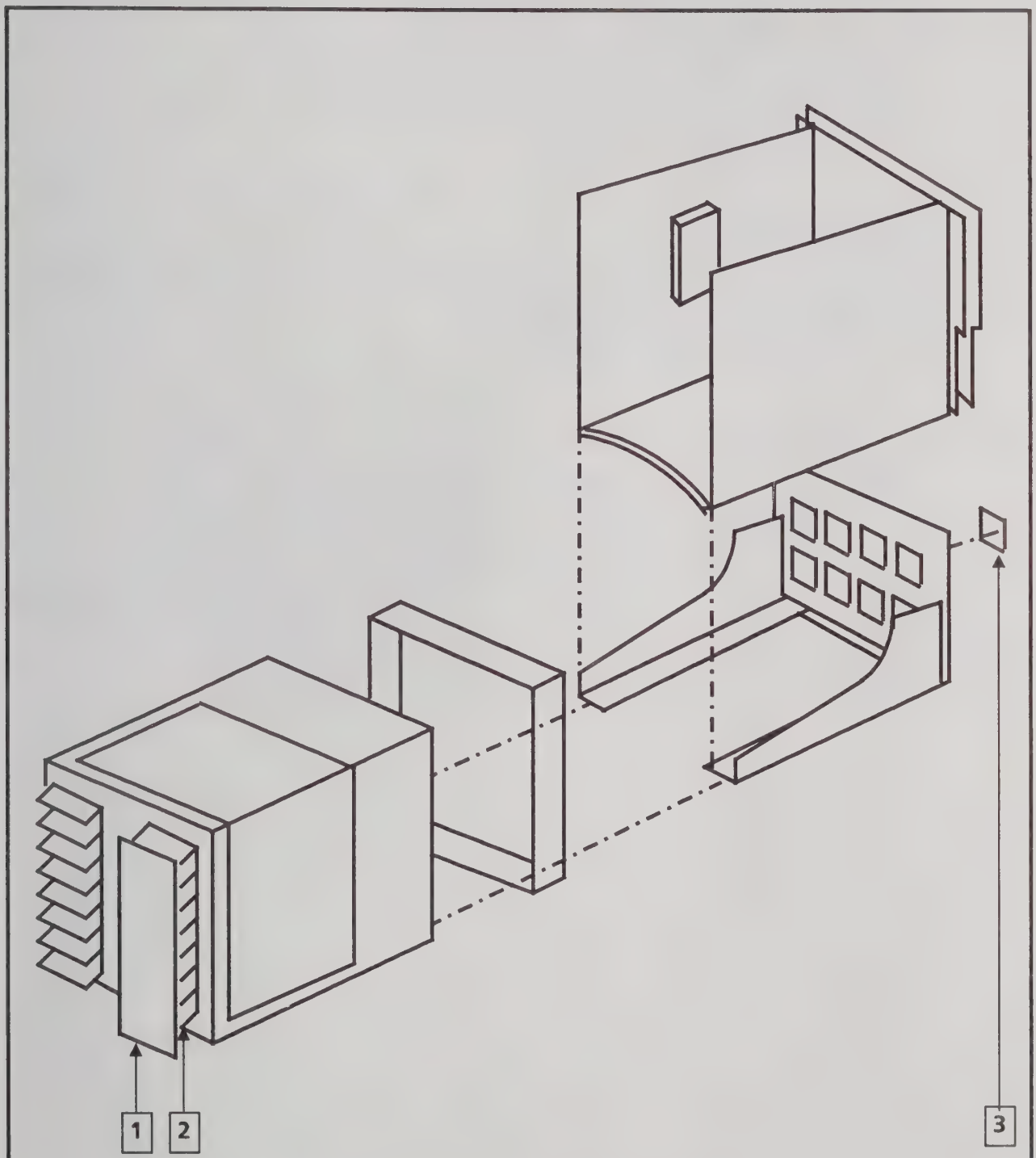


Figure 7-1 Exploded view of the Mini-Pro Limit Controller

UDC 2000 Mini-Pro Limit Controller Parts List

KEY NO.	PART NUMBER	DESCRIPTION	QUANTITY
1	30756091-001	Rear Terminal Cover Kit	1
2	30754142-003	Terminal Strip	1
3	30755754-001	Plug Button Kit (10 Buttons)	1

PARTS KITS NOT SHOWN

- A mounting kit, part no. 30755050-001
- A splash cover, part no. 24400107-001
- An adapter kit for DIN 43700 Panel Cutout(5.43 in. X 5.43 in.) to fit Dialatrol, Barber-Coleman 560, and Leeds and Northrup E Max V cutout, part no. 30755223-001(Full DIN)
- An adaptor plate with hardware to cover UDC 300 or UDC 4000 Cutout, part no. 30755223-002
  Additional 1/4 DIN adaptor plates with mounting hardware (see table7-1)

TABLE 7-1 1/4 DIN Adaptor Plates

DIMENSIONS				MAXIMUM CUTOUT				PART NUMBER
INCHES		CENTIMETERS		INCHES		CENTIMETERS		
WIDTH	HEIGHT	WIDTH	HEIGHT	WIDTH	HEIGHT	WIDTH	HEIGHT	
5.25	8.875	13.3	22.5	4.5	8.125	11.4	20.6	24400104-001
8.25	7.25	21.0	18.4	7.5	6.5	19.0	16.5	24400104-003
8.375	8.875	21.3	22.2	7.625	8.125	19.3	20.6	25500104-004
9.875	10.875	25.1	27.6	9.125	10.125	23.1	25.6	24400104-005

APPENDIX A

SECTION 8

INTRODUCTION

This Appendix provides information for all the user configurable parameters listed in the configuration section. If you aren't familiar with these parameters, this appendix gives you a definition of how each parameter setting affects controller performance. It will also refer you to any other prompts that might be affected by your selection.

PARAMETER GROUPS AND PROMPTS

As shown in the Table of Contents, the information is divided into 5 configuration groups which are accessed by pressing the **[SET UP]** key.

Each of these groups contain prompts, viewed in the lower display, which deal with functions that are pertinent to that particular group. These are accessed by pressing the **[FUNC]** key.

The selections or values are listed in the upper display. Refer to the Configuration section for step by step instructions.

TABLE OF CONTENTS

Group	**Page**
Lockout	8-2
Limit	8-3
Input 1	8-4
Options	8-5
Alarm 1	8-6
Calibration	8-7
Status Test Data	8-7

LOCK

Three levels of keyboard security protect Configuration and Calibration data.

LOCK

LOCKOUT applies to one of the functional groups: Configuration and calibration. DO NOT CONFIGURE THIS UNTIL ALL CONFIGURATION IS COMPLETE.

NONE

No Lockout -- all groups read/write.

CAL

Calibration is deleted from the SETUP list.

CONF

Lockout is read/write. All other groups are read only.

LIMIT

This data deals with the type of Limit Control you want, power up Logic, set point high and low limits, and the default display.

Lo or HI

Lo

LOW LIMIT CONTROL - latching relay de-energizes when PV goes below configured set point. Cannot be reset until PV rises above configured set point.

Hi

HIGH LIMIT CONTROL - latching relay de-energizes when PV goes above configured set point. Cannot be reset until PV drops below configured set point.

POWRUP

RST

RESET - after power down, controller latching relay will have to be reset.

NORM

NORMAL - after power down, controller will operate normally in same mode as before power was removed unless a limit has been exceeded. If the limit was latched at power down, the unit will be in "LIMIT" at power up and have to be reset..

SP HI

SET POINT HIGH LIMIT - this selection prevents the set point from going above the value selected here. The setting must be equal to or less than the upper range of the Input .

Range 0 to 100% of input in engineering units

SP LO

SET POINT LOW LIMIT - this selection prevents the set point from going below the value selected here. The setting must be equal to or greater than the lower range of the Input .

Range 0 to 100% of input in engineering units

DISPLY

If configured, the Set Point will be displayed in the upper display. "SP" will appear in the lower display.

PROC - PV will be displayed in the upper display.

INPUT1

These are the parameters required for input 1; temperature units, decimal location, actuation, high and low range values in engineering units, bias, filter.

DECMAL

DECIMAL POINT LOCATION -- This selection determines where the decimal point appears in the display.

None
One Place
Two Places

UNITS

TEMPERATURE UNITS -- This selection will affect the indicator. What display of temperature do you want.

F = Degrees Fahrenheit
C = Degrees Celsius
None = None

IN1TYP

INPUT 1 ACTUATION TYPE -- This selection determines what actuation you are going to use for input one.

b	B thermocouple
E H	E thermocouple high
E L	E thermocouple low
J H	J thermocouple high
J L	J thermocouple low
K H	K thermocouple high
K L	K thermocouple low
N	Ni Ni Moly thermocouple
R	R thermocouple
S	S thermocouple
T H	T thermocouple high
T L	T thermocouple low
W	W thermocouple
100H	100 ohm RTD high
100L	100 ohm RTD low

IN1 HI
IN1 LO

These prompts appear but are not configurable.

BIAS 1

BIAS ON INPUT 1 -- Select the bias value you want on input one.

RANGE

-10 to +10

FILTR1

FILTER FOR INPUT ONE -- A software digital filter is provided for input 1 to smooth the input signal. You can configure the first order lag time constant from 0 to 120 seconds. If you don't want filtering, enter 0.

NOTE: On all thermocouple actuations, Upscale burnout is provided for high limit control; Downscale burnout is provided for low limit control.

OPTONS

Two optional features are available: External Reset (Contact Input) and PV(Auxiliary) Output.

EXTRST

EXTERNAL RESET (CONTACT INPUT) resets the latching relay on contact closure.

DIS

Disable the external reset option

ENAB

Enables the external reset option. Contact closure resets the latching relay.

AUXOUT

AUXILIARY OUTPUT SELECTION provides a voltage output representing the process variable. The display for auxiliary output viewing will be in engineering units.

Other prompts affected by this selection: "0PCT" and "100PCT."

NONE

No auxiliary output

PROC

PROCESS VARIABLE -- Represents the value of the Process Variable.

0 PCT

PV (AUXILIARY) OUTPUT LOW SCALING FACTOR -- Use a value in engineering units for Process Variable.

100 PCT

PV (AUXILIARY) OUTPUT HIGH SCALING FACTOR -- Use a value in engineering units for Process Variable.

ALARMS

An alarm is an indication that an event that you have configured (for example--Process Variable) has exceeded one or more alarm limits. There are two set points. You can configure each of these two set points to alarm on the process variable. There are two alarm output selections, High and Low. You can configure each set point to alarm either on High or Low. These are called single alarms. You can also configure the two set points to alarm on the same event and to alarm both high and low. There is a Fixed Alarm Relay Hysteresis of 0.5% of Input (PV) span.

A1S1VA

ALARM 1 SET POINT 1 VALUE -- This is the value at which you want the alarm type chosen in Prompt "A1S1TY' to actuate. The value depends on what the alarm set point has been configured to represent.

A1S2VA

ALARM 1 SET POINT 2 VALUE -- This is the value at which you want the alarm type chosen in Prompt "A1S2TY" to actuate. The value depends on what the alarm set point has been configured to represent.

A1S1TY

ALARM 1 SET POINT 1 TYPE -- Select if you want set point 1 of alarm 1 to represent the process variable or deviation.

NONE No alarm

PROC Process Variable

DEV Deviation

A1S2TY

ALARM 1 SET POINT 2 TYPE -- Select what you want set point 2 of alarm 1 to represent. The selections are the same as A1S1TY.

A1S1HL

ALARM 1 SET POINT 1 STATE -- Select whether you want the alarm type chosen in Prompt "A1S1TY" to alarm HIGH or LOW.

HI High alarm

LO Low alarm

A1S2HL

ALARM 1 SET POINT 2 STATE -- Select whether you want the alarm type chosen in Prompt "A1S2TY" to alarm HIGH or LOW.

HI High alarm

LO Low alarm

CAL

The prompts used here are for field calibration purposes. Refer to the Calibration section in this manual for complete information.

READ

The prompts used here are for determining the reason for a controller failure. Refer to the Troubleshooting section in this manual for complete information.

APPENDIX B

SECTION 9

HOW TO APPLY DIGITAL INSTRUMENTATION IN SEVERE ELECTRICAL NOISE ENVIRONMENTS

Introduction

Products which incorporate digital technology provide recognized performance advantages over conventional analog instrumentation used for process control. These advantages can result in better product uniformity and greater overall efficiency when used correctly.

There are, however, certain guidelines regarding installation and wiring which must be carefully followed in order to achieve this performance. In addition to the traditional precaution of the separation of signal and power wiring in separate conduits, other measures must be taken to minimize the effects of electromagnetic interference (EMI) and radio frequency interference (RFI) on the operation of the equipment. Otherwise, if high level, short duration, noise spikes are permitted to enter the digital equipment, the noise can be transferred into the system's logic networks and can be misinterpreted as signal data, resulting in erroneous system operation and other unpredictable responses.

Potential Noise Sources

Noise can enter electronic equipment via three methods of coupling, namely:

- capacitive (or electrostatic)
- inductive (or magnetic)
- impedance

Capacitive and inductive coupling have the same essential effect -- they couple current or voltage, without any actual connection of the two circuits. Impedance coupling requires a connection between the two circuits.

Typical noise-generating sources that could affect electronic equipment through capacitive and inductive coupling include:

- Relay coils
- Solenoids
- AC power wires -- particularly at or above 100 Vac
- Current carrying cables
- Thyristor field exciters
- Radio frequency transmissions

Impedance couple noise may enter by way of the lines used to power the digital equipment or by way of improper grounding. Most power lines, at typical industrial locations, are far from noise-free. The noise on them can be generated in many ways, but are nearly always associated with switching circuits of some nature.

These include:

- large relays
- contactors
- motor starters
- business and industrial machines
- power tools
- HID (High Intensity Discharge) lights
- Silicon Controlled Rectifiers (SCRs) that are phase angled fired.

These are three ways to prevent electrical noise from interfering with the operation of the electronic digital equipment. One is to suppress the noise at its source. This is the most effective but also the most difficult because it is not easy to identify all of the potential noise sources in a typical industrial installation. Therefore, "suppression" is usually a last resort for those extreme situations where the other methods are insufficient by themselves.

The second method is to prevent noise from getting on the signal and power lines that are connected to the equipment. This is achieved by proper separation and shielding of those lines. In some cases separate power lines or special power line regulation or filtering may be required for satisfactory electronic digital equipment operation. It is the responsibility of the installer to follow good wiring practices.

The third method is to design the digital equipment with a high degree of noise rejection built-in. This includes housing the equipment in a case that will provide shielding, liberal use of noise rejection filters and opto-isolators, and the use of noise suppressors on potential noise sources within the equipment itself. This, of course, is the responsibility of the manufacturer who usually performs extensive laboratory and field testing of newly designed digital equipment to insure the adequacy of its immunity to noise. As a minimum requirement, the equipment should be able to pass the tests outlined in the IEEE Standard 472-1974 (Surge Withstand Capacity Tests).

Recommended Wiring Practices

- All wiring must conform to local codes and practices.
- Wires carrying similar types of signals (Table 9-1) may be bundled together, but bundles with different types of signals must be kept separated to prevent inductive or capacitive coupling.
- For distances over five (5) feet, and when shielding is recommended, use a separate metal tray or conduit for each bundle. Where conduits or trays are not practical, use twisted wires with a metal

overbraid and provide physical separation of at least one foot.

- Tray covers must be in continuous contact with the side rails of the trays.
- When unlike signal levels must cross, either in trays or conduits, they should cross at a 90-degree angle and at a maximum spacing. Where it is not possible to provide spacing, a grounded steel barrier or grid should be placed between the unlike levels at the crossover points.
- Trays containing low level wiring should have solid bottoms and sides. Tray covers must be used for complete shielding. Tray cover contact with side rails must be positive and continuous to avoid high reluctance air gaps, which impair shielding. Trays for low level cables should be metal and solidly grounded.
- Wires containing low level signals should not be routed near any of the following:
  - contactors
  - motors
  - generators
  - radio transmitters
  - wires carrying high current that is being switched on and off
- Use a 12-gage (or heavier) insulated stranded wire for the ground connection. Attach it firmly to a proven good earth ground such as a metal stake driven into the ground.
- All shields should be grounded at one end only -- preferably the instrument end.

Power Source

The AC power for the digital electronic equipment must be within the voltage and frequency limits specified for that equipment. Attempts to operate outside the specified limits will result in no performance. For those installations where the supply voltage will not stay within the specified limits; a ferro-resonant transformer, for voltage resolution, should be used.

For protection against noise, the AC source for the digital electronic equipment should be independent of all other loads especially when switching loads are involved. For example, it should not provide power for air-conditioning, convenience outlets, lighting, motors, or similar noise generating devices. To obtain electrical isolation (Figure 9-1) a separate transformer is required to supply power to the digital equipment. For additional noise and transient rejection, shielded primary and secondary windings may be required. And if necessary, power line filters may be added to attenuate noise signals that have a higher frequency than the power line frequency.

TABLE 9-1 -- External Wiring

Wire Function		Bundle No.	Are Shielded Twisted Wires Recommended?
No.	Type		
	HIGH VOLTAGE	1	NO
1	Line Power		
2	Earth Ground		
3	Line Voltage		
	Digital I/O		
	ANALOG I/O	2	YES
4	Process Variable		
	RTD		
	Thermocouple		
	dc Millivolts		
5	Low Level (< 100V)		
	4-20 mA dc		
	1-5 Vdc		
	DIGITAL I/O	3	YES
6	Low Voltage (< 100V)		
7	Computer Interface		

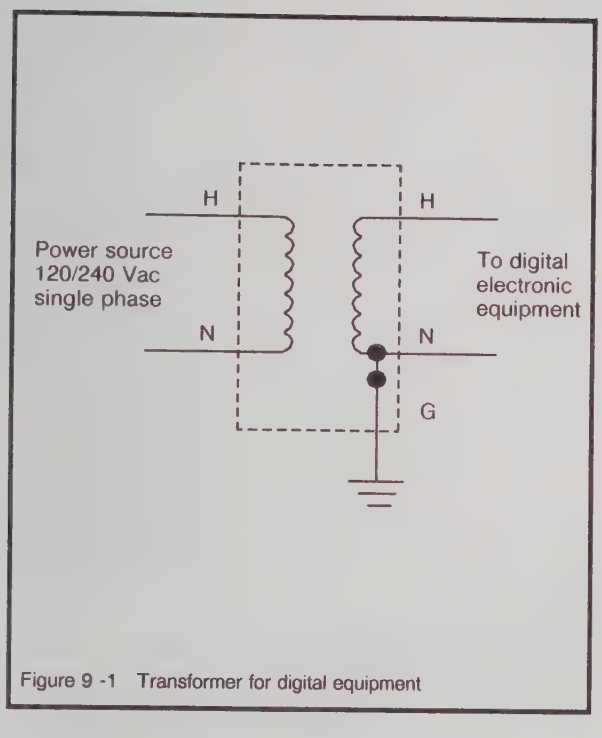


Figure 9 -1 Transformer for digital equipment

Noise Suppression at the Source

Generally speaking, when good wiring practices are used with well designed digital electronic equipment, no further noise protection is necessary. However, in some severe electrical environments, the magnitude of the electrical noise is so great that it must be suppressed at the source. In most control cabinets, the main sources of noise are motor starters, contactors, relays, and switch gear. For this reason, many manufacturers of these devices supply "surge suppressors" which mount directly on the noise source, for example, on the coil of a control relay or motor starter.

For those devices that do not have accessory "surge suppressors," resistance-capacitance (RC) circuits and/or voltage limiters such as metal varistors may be added when and where needed. This can be broken down into two categories, namely inductive loads(e.g., a relay switch in series with a relay coil) and contacts.

- Inductive Coils: Metal Oxide Varistors (MOVs) are recommended for transient suppression in inductive coils. An MOV is connected in parallel with the coil and is as close as physically possible to the coil (Figure 9-2). MOV devices (Table 9-2) are recommended for general purpose applications.

TABLE 9-2 -- MOV Devices

Honeywell Part Number	30732481-001	30732481-002
Maximum AC	130V	275V
Energy Pulse Rating	10 Joules	15 Joules
Supplier (General Electric)	V130LA10A	V275LA15A

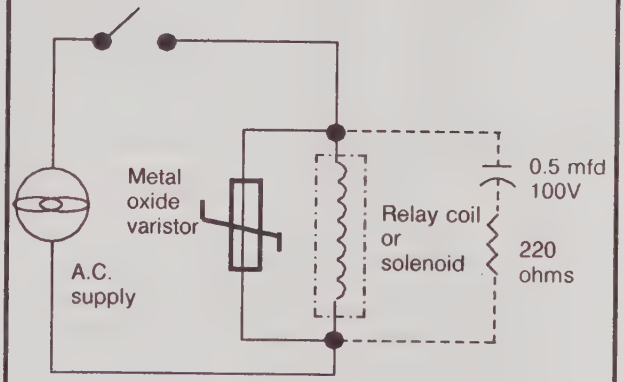


Figure 9-2 Transient suppression in inductive coils

Noise Suppression at the Source (continued)

Additional protection may be provided by adding an RC circuit in parallel with the MOV. This consists of a 220 ohm resistor in series with a 0.5 microfarad, 1000V capacitor. The power rating of the resistor will depend on the voltage rating of the coil (Table 9-3).

TABLE 9-3 --
Coil Voltage vs Resistor Voltage Rating

Coil Voltage	Resistor Voltage Rating
115V	1/4 Watt
230V	1 Watt
460V	3 Watt
550V	5 Watt

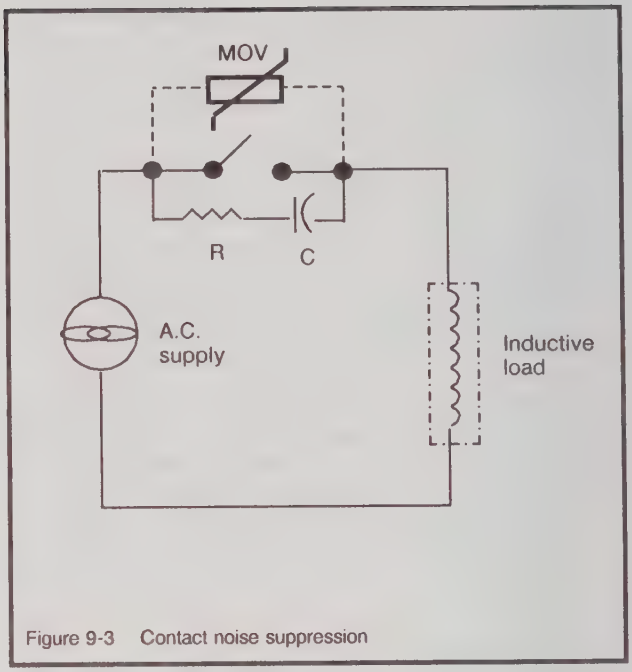


Figure 9-3 Contact noise suppression

- *Contacts:* When a contact interrupts an inductive load, a certain amount of energy is stored in the load. A MOV or RC circuit in parallel with the load provides a place where this energy may be dissipated. However, if there is no MOV or RC circuit, the energy may create a visible electrical arc across the open contacts. And this, in turn, results in electrical noise as well as damage to the contacts.

  One way to eliminate this arc is to connect a resistor and capacitor across the contacts (Figure 9-3). A combination of 47 ohms and 0.022 microfarads (1000 Vdc) is recommended for circuits up to 3 amps and 300 Vac. (NOTE 1) And for voltage above 2000 Vac, an MOV across the contact may be added for extra protection.

  For large load currents, a rule-of-thumb is to size the capacitor so that the number of microfarads equals the number of amperes in the load current, and the resistor is the same value as the load. This objective is to eliminate the visible arc.

  Either discreet resistors and capacitors or packaged RC networks may be used. An RC network (47 ohms and 0.1 microfarad) is available from Honeywell as part number 30371852-001. Similar RC networks are available from Electrocube Inc. (part number RG1782-3) and from Industrial Condensor Corporation.

  In DC circuits, the power dissipation under steady-state condition can be eliminated by placing a diode (in series with a resistor) in parallel with the load (Figure 9-4). The value of R should be less than or equal to the DC resistance of the inductive load.

NOTE 1: *For very small relay loads, a larger value of C (figure 9-3) may keep the external relay energized.*

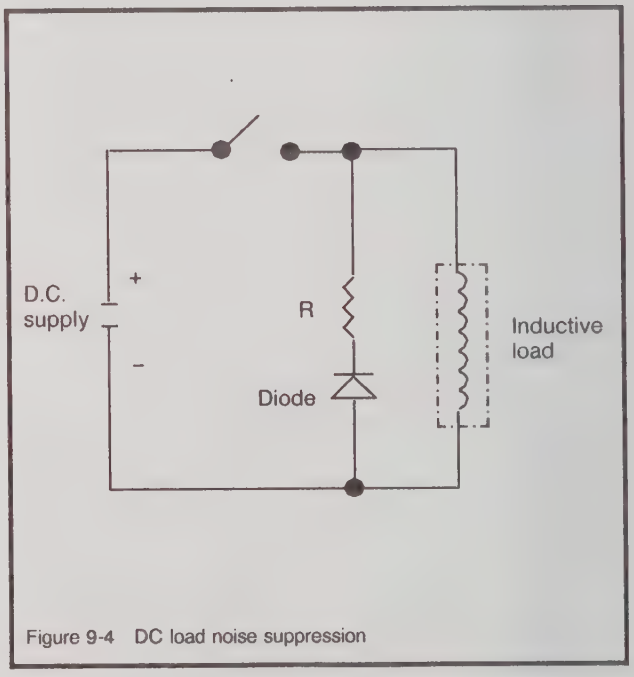


Figure 9-4 DC load noise suppression

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